NASA SP-7004 (02)

COMMUNICATIONS SATELLITES

A CONTINUING BIBLIOGRAPHY

WITH INDEXES

MAY 1966

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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NASA SP-7004 (02)

COMMUNICATIONS SATELLITES

A CONTINUING BIBLIOGRAPHY
WITH INDEXES

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA Information System during the period February, 1965–January, 1966.

Scientific and Technical Information Division
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. MAY 1966

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INTRODUCTION

With the publication of this second supplement, NASA SP-7004 (02), to the original issue of Continuing Bibliography on "Communications Satellites" (NASA SP-7004), the National Aeronautics and Space Administration continues its program of distributing selected references to reports and articles on aerospace topics that are currently under intensive study. The references are assembled in this form to provide a convenient source of information for use by scientists and engineers who need this kind of specialized compilation. Continuing Bibliographies are updated periodically by supplements which can be appended to the original issue. All references included in SP-7004 (02) have been announced in either *Scientific and Technical Aerospace Reports (STAR)* or *International Aerospace Abstracts (IAA)* and were introduced into the NASA information system during the period February, 1965–January, 1966.

The transmission of information by means of communications satellites is a new technique that promises to be a powerful stimulus for effective international cooperation in the investigation of space. In their flexibility of design, communications satellites also offer a multitude of opportunities for commercial and industrial development. The contents of this bibliography exemplify this diversity by including references to such topics as television broadcasting, telemetry, outer-space systems, multi-station systems, and medium-height, random-orbit systems. The economic and legal implications of communications satellite systems are represented. References are also included which describe the history and operation of individual satellites such as Advent, Courier, Echo, Relay, Score, Syncom, and Telstar, as well as several satellites used for meteorological studies.

Each entry in the bibliography consists of a citation and an abstract. The listing of entries is arranged in two major groups. Report literature references are contained in the first group and are subdivided according to their date of announcement in *STAR*. The second group includes journal and book references, subdivided according to their date of announcement in *IAA*.

A subject index and a personal author index are included.

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(continued)

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For further details please consult the Introductions to *STAR* and *IAA*, respectively.

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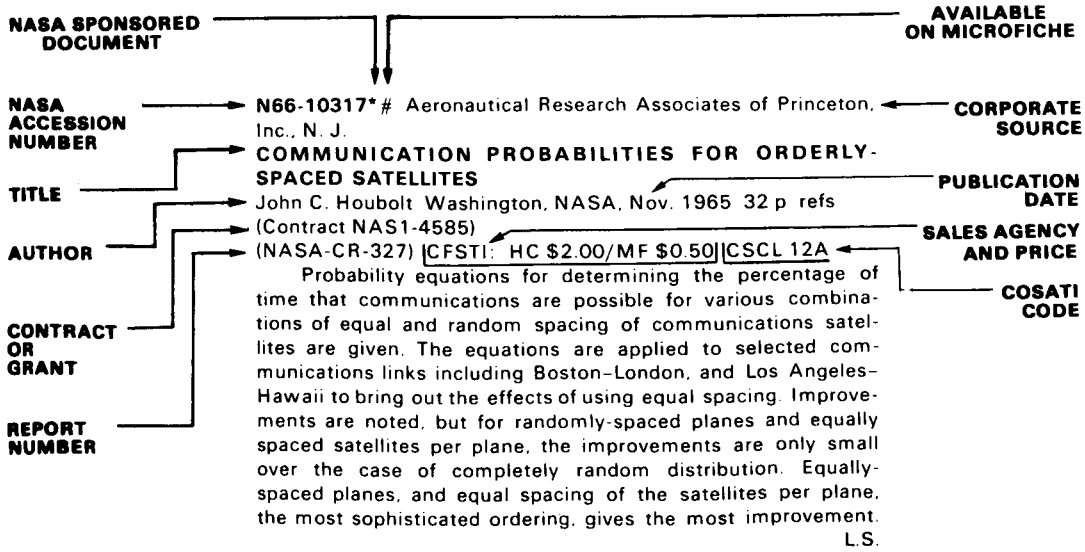

COMMUNICATIONS SATELLITES

a continuing bibliography with indexes MAY 1966

1965
STAR ENTRIES

N65-15310# Aerospace Corp., El Segundo, Calif. Electronics Research Lab.
FEASIBILITY STUDY OF SHAPED-BEAM ANTENNAS FOR THE DEFENSE COMMUNICATION SATELLITE PROGRAM
H. E. King, J. L. Wong, and C. J. Zamites, Jr. 27 Nov. 1964 60 p refs
(Contract AF 04(695)-269)
(SSD-TDR-64-257; TRD-269(4111)-12; AD-425028)

The feasibility of beam-shaping antennas for attitude controlled statellites orbiting at 5000 n. mi. is investigated. The improvement in gain of an ideal shaped-beam antenna is compared to the gain of a conventional horn-type antenna. Assumptions of the main beamwidth and sidelobe levels of the shaped beam are made to permit the comparison. Depending upon the stabilization error, the improvement is in the order of 3 to 3.5 dB along the horizon. The crossed-dipole reflector array, horn-lens (circular aperture) antenna, polyrod antenna, and multihorn array are treated analytically. In addition to the analyses, experimental studies of the horn-lens antenna and polyrod antenna are reported. The experimental polyrod antenna provides an improvement of approximately 2 dB. The experimental horn-lens antenna provides an 0.8 dB improvement. Considerations are given to the improvement expected from an attitude stabilized synchronous altitude satellite.
Author

N65-15488*# Virginia Polytechnic Inst., Blacksburg.
CONFERENCE ON ARTIFICIAL SATELLITES, PART B
Aug. 1964 295 p refs Conf. held at Va. Polytech. Inst., Blacksburg, 12–16 Aug. 1963 *Its* Bull., Eng. Expt. Sta. Ser. No. 156, Vol. 57, No. 8
(Contract NASr-226)
(NASA-CR-60132) OTS: HC $6.00/MF $1.50

CONTENTS:

SOLAR SPACE ENVIRONMENT

1. THE ORBITING ASTRONOMICAL OBSERVATORY AND THE ORBITING SOLAR OBSERVATORY N. G. Roman (NASA. Washington) 13 p (See N65-15489 06-30)

2. SOLAR AND STELLAR RADIATIONS ABOVE THE EARTH'S ATMOSPHERE T. A. Chubb (Naval Res. Lab.) 48 p (See N65-15490 06-29)

3. THE ATMOSPHERE AND SURFACE FEATURES OF MARS H. Spinrad (JPL) 20 p refs (See N65-15491 06-30)

4. SOLAR FLARES AND THE ASSOCIATED EJECTION OF PARTICLES E. Tandberg-Hanssen (High Altitude Observatory) 9 p (See N65-15492 06-29)

METEOROLOGICAL AND COMMUNICATION SATELLITES

5. TIROS — THE FIRST METEOROLOGICAL SATELLITE R. M. Rados (NASA. Goddard Space Flight Center) 55 p (See N65-15493 06-31)

6. THE NIMBUS SPACECRAFT SYSTEM H. Press (NASA. Goddard Space Flight Center) 61 p (See N65-15494 06-31)

7. PASSIVE COMMUNICATIONS SATELLITES W. J. O'Sullivan, Jr. (NASA. Langley Res. Center) 49 p ref (See N65-15495 06-31)

8. ACTIVE COMMUNICATION SATELLITE SYSTEM D. Mitchell (Bell Telephone Labs.) 31 p (See N65-15496 06-31)

N65-15495* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
PASSIVE COMMUNICATIONS SATELLITES
William J. O'Sullivan, Jr. *In* Va. Polytech. Inst. Conf. on Artificial Satellites, Pt. B Aug. 1964 49 p ref (See N65-15488 06-31) OTS: HC $6.00/MF $1.50

A passive communications satellite provides the link between the satellites themselves and the ground transmitting and receiving stations. This study includes: (1) the physical characteristics of the passive system; (2) the basic transmission theory of communications satellites and the equations substantiating the theory; (3) a comparison of the characteristics and economics of passive and active communications satellite systems; and (4) a review of advanced concepts for the development of more accurate passive communications satellites, with application to Echo II.
R.E.S.

N65-15496* Bell Telephone Labs., Murray Hill, N.J.
ACTIVE COMMUNICATION SATELLITE SYSTEMS
Doren Mitchell *In* Va. Polytech. Inst. Conf. on Artificial Satellites, Pt. B Aug. 1964 31 p (See N65-15488 06-31) OTS: HC $6.00/MF $1.50

Telstar experiments are discussed as an example of an active communications system. Medium-orbit and high-orbit systems are related to the engineering advantages of each. The high-orbit system with three 24-hour satellites is shown to require a simpler ground station network and to offer better coverage with fewer vehicles than the low-orbit system. The disadvantages of the high-orbit system are the circuit link delay and the problem of insertion into and maintenance of the 22 000 mile orbit.
R.E.S.

N65-15498* Radio Corp. of America, Princeton, N.J.
PROJECT RELAY
John D. Kiesling *In* Va. Polytech. Inst. Conf. on Artificial Satellites, Pt. C Aug. 1964 11 p (See N65-15497 06-31) OTS: HC $5.00/MF $1.00

The communications satellite Relay is described in terms of communication system, command, tracking, telemetry, power supply, stabilization, and attitude control. The objectives of the program were: (1) to investigate wideband communications between distant ground stations by low altitude orbiting satellite; (2) to measure the effects of the space environment on a satellite; (3) to develop operational experience in the use of such a system; (4) to measure radiation damage to critical components; and (5) to monitor radiation encountered at the orbital altitudes. About 2000 orbits were completed; and successful relay of television, telephone, and other data transmissions between North America and Europe and two-way telephone service between North and South America were also completed. The trouble spots have been with intermittent failure of a series power transistor; equipment sometimes turns on and off without command, and radiation effects on solar cells have been marked. R.E.S.

N65-15554# Aerospace Corp., El Segundo, Calif. Satellite Systems Div.
DESIGN DIFFERENCES BETWEEN MILITARY AND COMMERICAL COMMUNICATION SATELLITES
W. L. Pritchard and Neil Mac Gregor Dec. 1964 53 p refs (Contract AF 04(695)-469)
(TDR-469(5111-01)-1; SSD-TDR-64-271; AD-453999)

A single satellite is considered first, and it is shown how military needs for security and survivability lead to one estimate of communication capacities, while the commercial desire for revenue leads to another (of higher capacity). Frequency selection is discussed, as is the effect of ground station configuration and data processing. Major system aspects are then covered with particular reference to coverage, survivability, communication reliability, multiple access, and launch economics. Typical system calculations are presented, followed by a brief discussion of the divergent growth potentials and interests of military and commercial systems. Discussions of communication satellites are clouded by several misconceptions and/or prejudices. The principal offenders, such as the differences between operational systems and experiments and the either/or nature of the arguments used, are discussed and put into perspective. Author

N65-15657*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
TELEMETRY INSTRUMENTATION OF THE ECHO II PASSIVE COMMUNICATIONS SATELLITE
Harold S. Horiuchi Oct. 1964 15 p refs Presented at the 8th Intern. Conv. on Mil. Electron. MIL-E-CON 8, Washington, D.C., 14–16 Sep. 1964
(NASA-TM-X-55117; X-621-64-281) OTS: HC $1.00/MF $0.50

An Echo II electronic beacon telemetry system is described that provides a tracking signal and monitors the skin temperature and measures the internal pressure of the satellite, with emphasis on data acquisition during the initial inflation stages. The system consisted of two redundant amplitude-modulated rf transmitters operating at Minitrack frequencies of 136.02 and 136.17 Mc. The rf power of the two beacons was about 35 to 39 milliwatts each. The package contains four solar modules for recharging of the batteries. Pressure and temperature readings were taken from the initial inflation state of the balloon and through two orbits and are presented in charts. Data on the varying rotation speed, and also on the location of the spin axis of the satellite are included. G.G.

N65-15947*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENTS TO DETERMINE COMMUNICATION CAPABILITY OF THE ECHO II SATELLITE
W. C. Nyberg, R. L. Kaiser, and W. E. Leavitt (Collins Radio Co., Dallas, Tex.) Oct. 1964 7 p Presented at the 8th Intern. Conv. on Mil. Electron., Washington, D.C., 16 Sep. 1964
(NASA-TM-X-55118; X-621-64-291) OTS: HC $1.00/MF $0.50

The experiments were divided into two categories: (1) to determine directly and quantitatively the characteristics of the Echo II satellite as a radiofrequency reflector; and (2) to demonstrate some of its communications capabilities. Tests in the first category included measurements of the received signal level, and provided data for the effective cross-sectional area of the satellite and for the signal fading and scintillation characteristics. The demonstrational type experiments included an audiofrequency transmission test utilizing tones, voice and music, and facsimile and digital data transmissions The experiments established the Echo II bandwidth capability at 12 Mc. The satellite had good transmission capabilities and met the design objective of becoming a rigidized structure. G.G.

N65-16014# Rome Air Development Center, Griffiss AFB, N.Y.
ANALYSIS OF DOPPLER DATA FROM ECHO II
Edward E. Cossette Nov. 1964 36 p refs
(RADC-TDR-64-444; AD-610120)

Measurements were made using the Passive Satellite Research Terminal at the Floyd test site. Prior to these measurements, orbital element data received from space track agencies were used to predict the expected doppler frequency as a function of time in an on-site digital computer. The computed doppler frequency was subtracted from the measured doppler frequency every second to obtain the doppler difference. The results of the data revealed that a sizable time error existed in the computed data. This resulted in much larger doppler uncertainties than were expected. Author

N65-16296# Air Force Systems Command, Wright-Patterson AFB, Ohio. Systems Engineering Group
THE RELATIVE MOTIONS OF TWO INDEPENDENT COMMUNICATION SATELLITES Technical Documentary Report, Sep. 1962–Apr. 1964
Donald R. Shover Sep. 1964 84 p
(SEG-TDR-64-44, AD-608809)

This report presents a method of determining the relative positions of two independent communication satellites and the times during which these two satellites are in the proper positions for two specified modes of communication. The method developed is to be used in support of two separate satellite experiments to determine if communication is possible between two satellites, which are physically out of line of sight of each other, via bending and reflecting radio waves in and through the ionosphere. Presented is a mathematical model that determines the positions of two independent satellites as a function of time in the earth coordinate system in terms of colatitude, longitude, and altitude. Both satellites are tracked from their injection points throughout their orbits in finite-time increments for a preselected time. In conjunction with determining the positions of the satellites, the model also determines the time, with respect to some given time reference, when the satellites enter and leave the line of sight of any set of designated geographical positions as well as when the satellites enter and leave the line of sight of each other. The recorded times are summed, and the percentages of the recorded times, based on the total time considered, are determined. Author

N65-16428*# RAND Corp., Santa Monica, Calif.
THE MARKET FOR OVERSEAS TELECOMMUNICATIONS IN 1970
Robert L. Slighton Sep. 1963 67 p refs
(Contract NASr-21(01))
(NASA-CR-55293; RM-3831-NASA) OTS: HC $3.00/MF $0.75

This memorandum investigates the question of the size and configuration of the market for overseas telecommunications services in the year 1970. It is designed to provide background information of use to officials of the National Aeronautics and Space Administration and other Government agencies responsible for communications satellite research and development policy. Author

N65-16435*# RAND Corp., Santa Monica, Calif.
HIGH-CAPACITY SUBMARINE TELEPHONE CABLES: IMPLICATIONS FOR COMMUNICATION SATELLITE RESEARCH AND DEVELOPMENT
R. T. Nichols 30 Sep. 1963 47 p refs
(Contract NASr-21(01))
(NASA-CR-55290; RM-3877-NASA) OTS: HC $2.00/MF $0.50

The demand for channels provided by any type of communication facilities, for example, communications satellite facilities, depends among other things, on the costs of channels provided by alternative systems. The main significance of the new submarine cables is that they promise to lower the costs of conventional channels on high-volume routes, thus lessening the demand for communications satellite channels on these routes. It has often been supposed that communications satellites would be economically attractive, relative to conventional communications facilities, for long-distance, overwater, large capacity routes. The emphasis on long distance is well grounded. The reason is that the cost of satellite circuits is independent of circuit length. The emphasis on overwater is less well grounded. The cost of satellite circuits overseas is the same as the cost of satellite circuits overland; on the other hand, submarine cable circuits are probably no more expensive than landline circuits in many areas of the world, and they cost perhaps only twice as much as landline circuits in the United States. Author

N65-16488*# Stanford Research Inst., Menlo Park, Calif.
HIGH-DEFINITION PHOTOGRAPHY OF PROJECT ECHO I SATELLITE Final Report
R. H. Weitbrecht Jul. 1963 48 p refs
(Contract NASr-49(03); SRI Proj.-3890)
(NASA-CR-53146) OTS: HC $2.00/MF $0.50

Results of high-definition photography of the balloon satellite Echo I are presented. Due to poor seeing as well as to photographic difficulties caused by the specular reflectivity of the object, efforts to delineate the shape of the balloon are inconclusive. A model experiment was undertaken to show what results would be obtained using a satellite coated with various proportions of specular and diffuse reflectivities. Feasibility of photographing a satellite on a flyby, using a fixed telescope system with an image motion-compensating camera, is demonstrated. Author

N65-17370*# National Aeronautics and Space Administration, Washington, D. C.
THE NATIONAL SPACE PROGRAM: HIGHLIGHTS OF THE PAST YEAR AND PROJECTS FOR THE FUTURE
James. E. Webb 23 Feb. 1965 18 p Address presented to the Joint Tech. Soc., Poughkeepsie, N. Y., 23 Feb. 1965 Available from the Scientific and Technical Information Division

Mr. James E. Webb from the National Aeronautics and Space Administration, presents NASA's plans and programs over a broad spectrum. Highlights from last year's achievements are pointed out with emphasis on the meteorological satellite program and the communications satellite program. Some areas of future research are outlined and NASA's participation and sponsorship in space-related research and development is discussed. G.G.

N65-18246# Pennsylvania Univ., Philadelphia. Moore School of Electrical Engineering
SYSTEM STUDY FOR SUPER MOBILE COMMUNICATIONS SATELLITE GROUND STATION Final Report, 1 Apr.–31 Aug. 1964
F. Haber, M. Akiyama, J. Feld, R. Harper, R. Moff et al 30 Oct. 1964 190 p
(Contract DA-36-039-AMC-03219(E))
(Rept.-65-06; AD-609314)

A systems analysis of a highly mobile ground terminal for use with a space communication system is presented, together with recommendations covering various subsystems, and the values of their important parameters. These recommendations are grounded upon an analysis aimed at minimizing overall system weight and complexity. Approximate relations between the subsystem property (gain, sensitivity, or power output) and its weight, based upon current practice, were developed for the systems analysis. The broad conclusion drawn is that the requirements can be satisfied using currently available components. A detailed report is given on analyses (1) to determine computational methods for rapidly establishing regions of mutual visibility between ground stations, and for determining accurate pointing instructions to the antenna; (2) of the output characteristics of PCM systems using error correcting codes; and (3) of the effective noise temperature of an antenna as a function of the angle of tilt. Author

N65-18261*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE ROTATION OF SYNCOM III DURING LAUNCH
David L. Mott (New Mexico State Univ.) Oct. 1964 17 p refs
(NASA-TM-X-55139; X-621-64-294) OTS: HC $1.00/MF $0.50

An analysis was made of telemetry data from Syncom III covering the launch period from spinup to third-stage/spacecraft separation. The early spin history of the satellite is given, and its torque-free motion before and after separation is described. The observed torque-free motion is shown to be consistent with theory. From the data, values of the ratio of roll-to-pitch moments of inertia are calculated both for the burned-out Delta third-stage with payload and for the separated spacecraft. Author

N65-20112*# Hughes Research Labs., Malibu, Calif.
MULTIPLE ACCESS SATELLITE COMMUNICATION Final Report, 20 Aug. 1962–20 Aug. 1963
S. G. Lutz [1963] 74 p refs
(Contract NASw-495)
(NASA-CR-57530) CFSTI: HC $3.00/MF $0.75

Problems relating to future multiple-access satellite communications systems are studied. The work performed is classified in two categories: (1) frequency sharing—determining the antenna azimuth arcs of surface microwave stations permitting beamed interference with satellites in any given circular equatorial orbit; and (2) system—an orbital aspect of multiple access systems, and the overlap of coverage areas of two satellites as a function of their height and separation. An attempt

is made to arrive at an antenna pattern approximation typifying an average microwave relay antenna and its usage, and to determine the relative importance of beam and sidelobe interference components at the satellite's receiver. It seems that a time-division multiple satellite system would need to offer compelling advantages, to be acceptable to the world's telecommunication industry. Since the satellite system will be a "common carriers' carrier," its competitiveness will depend on its cost compared with equivalent surface communication costs, without reference to the additional cost for user-to-station surface communication. R.W.H.

N65-21001*# National Aeronautics and Space Administration, Washington, D. C.
THE GERMAN GROUND STATION FOR INTERCONTINENTAL SATELLITE COMMUNICATIONS [DIE DEUTSCHE ERDEFUNKSTELLE FUR DEN INTERNATIONALEN SATELLITEN-NACHRICHTENVERKEHR]
Ernst Dietrich Apr. 1965 49 p refs Transl. into ENGLISH from Jahrb. Elek. Fernmeldewesens (Windsheim), 1964 p 265–312
(NASA-TT-F-9306) CFSTI: HC $2.00/MF $0.50

A Government owned and operated ground station for radio, television, facsimile, and multichannel telephone transmission over the communications satellites Telstar and Relay, as part of a NASA program, is described. The station works with a broadband and a narrowband installation, the latter being a mobile unit manufactured by International Telephone and Telegraph Corporation. The basic principles of both systems are described, with special emphasis on the 25-m Cassegrain antenna with parabolic horn feed, unique in design. Layout, technical data, monitoring equipment, and design features are tabulated, plotted, and shown in photographs. Author

N65-21163*# National Aeronautics and Space Administration, Washington, D. C.
COMMUNICATIONS SATELLITES—A CONTINUING BIBLIOGRAPHY
Apr. 1965 62 p
(NASA-SP-7004(01)) CFSTI: HC $1.00/MF $0.75

N65-21661*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
STUDY OF AN R. F. TO R. F. SATELLITE TRANSPONDER
Walter K. Allen, Louis J. Ipolito, and Clay Prillaman Feb. 1965 132 p refs
(NASA-TM-X-55193; X-625-65-41) CFSTI: HC $4.00/MF $1.00

A program was conducted to investigate the feasibility of a wideband, direct rf to rf conversion communication satellite transponder, utilizing a TWT in a reentrant mode. After amplification by the TWT, the signal(s) are frequency translated and reamplified by the same TWT. Pre- and post-amplification is provided to establish system sensitivity and dc to rf conversion efficiency. The optimum transponder type and configuration were determined, fabricated, and evaluated. Analysis of the measured performance is presented with emphasis on the baseband distortion characteristics for both single and multiple signals. Unusual characteristics of the TWT as operated in the reentrant mode are also analyzed and presented. The gain, output power, and noise figure obtained with the reentrant transponder were established to be consistent with the basic requirements of a communication satellite. The major advantages offered are reduced transponder complexity and the extremely wide bandwidths which can be realized. Author

N65-21819# Institute for Defense Analyses, Washington, D. C. Research and Engineering Support Div.
MULTIPLE ACCESS TO A COMMUNICATION SATELLITE WITH A HARD-LIMITING REPEATER. VOLUME I: MODULATION TECHNIQUES AND THEIR APPLICATIONS
J. Kaiser, J. W. Schwartz, and J. M. Aein Jan. 1965 86 p refs (Contract ARPA SD-50)
(IDA-R-108, Vol. I; AD-457945)

Four modulation techniques applicable to a wideband nonlinear repeater and their characteristics are described. The first is the frequency-division multiple access (FDMA), in which the number of access channels obtainable is a function of the type of message modulation in each access channel, up-link power control, and the sensitivity of each of the receiver stations. The second is the spread-spectrum multiple access (SSMA). In constant-envelope SSMA each carrier signal usually occupies the entire repeater bandwidth. An access channel consists of a carrier waveform characterized by a distinct wideband angle modulation. The third technique is the time-division multiple access (TDMA) in which the transmissions in different links do not overlap in the repeater, and each link is assigned exclusive use of the repeater during specified time slots; in this manner, the signals pass through the repeater with no interaction. The fourth and last technique is the pulse-address multiple access (PAMA) in which the pulses within specific frequency bands and the intervals between the pulses in a given carrier waveform constitute a distinct pattern. The amount of time that pulse is present is much less than the amount of time no pulse is present. The same patterns are used to carry each message sample. R.W.H.

N65-21830 Radio Corp. of America, Princeton, N. J. Astro-Electronics Div.
RELAY SATELLITE COMMUNICATIONS SYSTEM
J. Kiesling, W. Maco, and S. Goldman *In* RCA, Camden Microwave Systems and Devices [1964] p 7–13 (See N65-21828 11-07)

Long-distance, high-capacity communications systems may be established using microwave repeaters in earth-orbiting satellites. The problems associated with the operation of these repeaters in the environment of outer space were explored using the Relay satellites. The performance objectives and design criteria for the repeaters in the Relay satellite are given, and the ground-station network is described. It is shown that the ground station network, the launch and orbiting constraints, and the outer space environment impose severe restrictions upon the design of this satellite system. The experience with the Relay satellites has shown, however, that a proper consideration of these restrictions, in addition to careful processing and testing, can result in long-lived performance in the space environment. Author

N65-21905 Radio Corp. of America, Princeton, N. J. Astro-Electronics Div.
CORRELATION OF ANALYTICAL AND SPACE CHAMBER THERMAL BALANCE DATA WITH FLIGHT DATA (TIROS AND RELAY)
E. A. Goldberg *In* ARO, Inc. 5th Ann. Symp. on Space Environment Simulation [1964] 22 p refs (See N65-21900 11-11)
(C-2126)

The Tiros spacecraft program demonstrated that, for a simple spinning spacecraft in a given orbit, it was feasible to predict analytically the orbital thermal conditions with reasonably small error. Thermal-vacuum testing of the Tiros spacecraft was limited to thermal soak testing. This proved adequate

for detecting weak components and component hot spots, but did not provide thermal balance data. The thermal gradient tests used on the Relay program appeared to be more reliable for predicting orbital spacecraft temperatures than were the tests employing a simple solar simulator and were less expensive. Results of both type tests were adequate. The more expensive solar simulation approach needs to be further refined to achieve better correlation. The probable added expense makes the isothermal shroud technique look even more attractive. All results demonstrated the soundness of using rather simple means, tailored for each particular spacecraft, to predict thermal balance. E.E.B.

N65-22174*# Perkin-Elmer Corp., Norwalk, Conn. Electro-Optical Div.
DETERMINATION OF OPTICAL TECHNOLOGY EXPERIMENTS FOR A SATELLITE, PHASE II Engineering Report No. 7924
Herbert F. Wischnia Feb. 1965 197 p refs
(Contract NAS8-11408)
(NASA-CR-62340) CFSTI: HC $5.00/MF $1.25

Earth satellite experiments are recommended which would advance the technology associated with deep space optical communications and diffraction limited optical systems in space. Block diagrams and further system analysis of experiments selected are presented. Also, the key issues of aperture and its effect on channel capacity for a deep space optical communication system were evaluated for a number of crucial parameters. Further, the laser communication performance curves were computed for diameters of 8, 16, 32, and 64 inches for quantum efficiencies of the detector equal to 8% and 100%. The calculations of channel capacity were concluded to provide a communications breakthrough over microwave communication systems. For a 32-inch aperture system, with a 100-milliwatt laser, the channel capacity was 5.2×10^6 bits/sec for 100% quantum efficiency of the sensor, or 0.42×10^6 bits/sec for a quantum efficiency of 8%. E.E.B.

N65-22732# Army Dept., Washington, D. C.
ARMY SCIENCE CONFERENCE PROCEEDINGS. VOLUME I: PRINCIPAL AUTHORS A THROUGH H
[1964] 526 p refs Conf. held at U.S. Military Acad., West Point, N. Y., 17-19 Jun. 1964
(AD-611432)

Papers given at the Army Science Conference are presented arranged by principal authors A through H. For individual titles see N65-22733-N65-22765.

N65-22735 Army Satellite Communications Agency, Fort Monmouth, N. J.
ARMY PARTICIPATION IN PROJECT SYNCOM
J. Wilson Johnston *In* Army Dept. Army Sci. Conf. Proc., Vol. I [1964] p 23-43 (See N65-22732 12-34)

The SYNCOM-SATCOM network in which communications satellites provide instantaneous relay of messages between intercontinental ground stations is described, and the results of a communications test are given. The SYNCOM spacecraft is a synchronous altitude satellite 28 inches in diameter and it weighs 85 pounds in orbit. The support complex consists of fixed terminals at Fort Dix in New Jersey, Camp Roberts in California, several transportable terminals, and one seaborne terminal aboard a U.S. Navy transport. Photographs of these terminals are shown. Satellite communication capability, 24-hour satellite earth orbital path, and the orbit configuration, are depicted. Results of a communications test using a single nominal 4-kilocycle voice channel are reported; a chart shows maximum and minimum signal levels over a 24-hour period, and the ratio of signal-plus-noise to noise for the 4-kilocycle baseband mode that offered best performance. In a special test, human psychological adjustment to 0.6-second round-trip delay with the echo suppressed was demonstrated in a test with 1000 participants. J.M.D.

N65-23569 Academy of Sciences (USSR), Moscow. Astronomical Council
REDUCTION OF SIMULTANEOUS SATELLITE OBSERVATIONS [OPYT OBRABOTKI SINKHRONNYKH NABLYUDENIY ISKUSSTVENNYKH SPUTNIKOV ZEMLI]
V. M. Amelin *In its* Opt. Observation Sta. of Artificial Earth Satellites, Bull. No. 39 Jun. 1964 p 3-8 refs In RUSSIAN; ENGLISH summary (See N65-23568 13-07)

Simultaneous tracking of satellites for geodetic purposes is discussed. Two problems are considered: estimation of satellite positions from simultaneous tracking data and of coordinates of an unknown station. Results of reduction of photographic simultaneous tracking data of the balloon-satellite Echo-I are given. Author

N65-23570 Academy of Sciences (USSR), Moscow. Astronomical Council
APPLICATION OF THE "GEOMETRICAL METHOD" FOR THE REDUCTION OF SIMULTANEOUS OBSERVATIONS OF ECHO-1 [PRIMENENIE "GEOMETRICHESKOGO METODA" K OBRABOTKE SINKHRONNYKH NABLYUDENII SPUTNIKA "EKHO-I"]
G. V. Panova and D. E. Shchegolev *In its* Opt. Observation Sta. of Artificial Earth Satellites, Bull. No. 39 Jun. 1964 p 8-10 refs In RUSSIAN; ENGLISH summary (See N65-23568 13-07)

An example of calculation of satellite positions and of the coordinates of a tracking station with the aid of formulas of the analytical geometry is given. Author

N65-23572 Academy of Sciences (USSR), Moscow. Astronomical Council
SIMULTANEOUS PHOTOGRAPHIC TRACKING OF ARTIFICIAL SATELLITES IN AN EXPEDITION [SINKHRONNYE FOTOGRAFICHESKIE NABLYUDENIYA ISKUSSTVENNYKH SPUTNIKOV ZEMLI V EKSPEDITSIONNYKH USLOVIYAKH]
A. G. Krylov and V. A. Jurevitch *In Its* Opt. Observation Sta. of Artificial Earth Satellites, Bull. No. 39 Jun. 1964 p 12-15 refs In RUSSIAN (See N65-23568 13-07)

Several temporary experimental photographic stations set up for synchronized observation of Echo I during May and June 1963 are described. Since these stations were functioning under expeditional conditions, the data obtained lack accuracy. Preparations for the expeditions, characteristics of the cameras used, analysis of the time deviations, description of the stations, and site selection are among the topics discussed. M.P.G.

N65-23712*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
DETERMINATION OF THE ELLIPTICITY OF THE EARTH'S EQUATOR FROM OBSERVATIONS ON THE DRIFT OF THE SYNCOM II SATELLITE
Carl A. Wagner Washington, NASA, May 1965 70 p refs
(NASA-TN-D-2759) CFSTI: HC $3.00/MF $0.75

An original, simple theory is presented for the radial and longitudinal drift regime, in a triaxial earth-gravity field, of an inclined 24-hour satellite with a near-circular orbit. This new theory shows that the inclined orbit regime is the same as the equatorial, modified only by an inclination factor. The theory is closely validated by two numerically integrated

particle drifts of about 3-months duration each. The particle program included best estimates of sun and moon gravity, longitude-independent (zonal) earth gravity through fourth order, as well as triaxial earth gravity (associated with equatorial ellipticity). On the basis of this validation, the actual drift of Syncom II over Brazil is reduced to yield the following two parameters of the earth's equatorial ellipticity:

$$J_{22} = -(1.70 \pm 0.05) \times 10^{-5}$$

(representing a 65 ±2 meter difference between major and minor equatorial radii); and $\lambda_{22} = -(19 \pm 6)^{\circ}$ (locating the geographic longitude of the major equatorial axis). These results show a somewhat stronger and west-shifted equatorial ellipticity than recent geodetic investigations in 1963–1964 indicate. Author

N65-23968# Eurospace, Paris (France).
PROCEEDINGS OF THE U. S.–EUROPEAN CONFERENCE HELD IN ROME ON THE 22–24 JUNE 1964
[1964] 47 p

Six papers on management which were presented by U.S. speakers are reported. Topics included *The Integration Tools of System Management*, focusing on the Minuteman system; *Cost Effectiveness in a Development Programme*, focusing on cost effectiveness as used to compare the performance of one program to another and as a decision making aid within existing programs, and the use of this concept in the Saturn program; *Testing of Booster Upper Stages*, focusing on the Agena vehicle; *Reliability and Environmental Testing of Spacecraft*, focusing on the selection of the correct level of reliability and the amount of testing required to attain this level; *Principles of Interface Management in Advanced Projects*, focusing on Syncom, Advanced Syncom, and Early Bird. Each paper contains a discussion in which comments of European speakers are included. Also included in the report is a list of papers available at EUROSPACE. S.C.W.

N65-23970# Hughes Aircraft Co., El Segundo, Calif. Communications Satellite Lab.
AN INTERNATIONAL COMMERCIAL COMMUNICATION SATELLITE SYSTEM
Harold A. Rosen Paris, EUROSPACE, [1964] 18 p Presented at the U. S.–European Conf., Rome, 22–24 Jun. 1964

A synopsis on the technical development of Syncom, a spin stabilized synchronous communication satellite, is presented. Data on performance, reliability, external and internal design features, cost, components, and launch configuration, are included. S.C.W.

N65-24872# European Space Vehicle Launcher Development Organization, Paris (France).
CLASSIFICATION OF MISSIONS OF SPACE VEHICLES LAUNCHED IN THE UNITED STATES [CLASSIFICATION DES MISSIONS DE VEHICULES SPATIAUX LANCES AUX ETATS-UNIS]
M. Gilli Jan. 1965 14 p In FRENCH
(ELDO-TM-F-14)

Tables giving the principal characteristics of missions carried out by space vehicles launched by the United States are given. Each table groups as many as possible of the satellites launched by the same launcher and, wherever possible, gives an indication of the source of electrical energy onboard the space vehicle. The different tables are devoted to purely scientific satellites, meteorological satellites, communications and navigation satellites, satellites with heavy low orbits, space probes, as many military satellites as known, and others including examples of multiple launchings by the same launcher. M.P.G.

N65-24918 National Academy of Sciences—National Research Council, Washington, D. C. Space Science Board
COMMUNICATIONS SATELLITES
In its U.S. Space Sci. Program, Rept. to COSPAR 1963 p 109–112 (See N65-24908 14-30)

Passive and active communication satellite programs are discussed. Experience with Echo I passive satellite in 1960 indicated the need for larger and more rigid spherical satellites capable of longer life, and for improved techniques for fabricating lighter satellites that are sufficiently rigid. Spheres 41 meters in diameter with a mylar sheet sandwiched between aluminum layers are being constructed to achieve 20 times greater buckling resistance than Echo I. Development of reflective space structures with gain superior to that of spheres is underway. Project Telstar, intended to investigate transmission of wideband signals from active satellites in earth orbit, and the specific objectives of Telstar I, are summarized. Project Relay objectives, and the first low-altitude Relay active satellite for testing solar cell life and measuring environmental radiation, are described. A detailed photograph of the Syncom active satellite is shown. J.M.D.

N65-26423*# California Univ., La Jolla. Physics Dept.
A SURVEY OF INNER ZONE PROTONS
R. W. Fillius and C. E. Mc Ilwain 13 Apr. 1965 50 p refs (Contract NASr-116; Grant NsG-538)
(NASA-CR-63420) CFSTI: HC $2.00/MF $0.50 CSCL 20H

This report presents detailed data from a survey of trapped protons made by Relay I. Six energy channels from 1.1 to 63 MeV are analyzed to determine the stationary distribution of trapped protons as of January 1, 1963. This data is presented as the observed flux of locally mirroring particles plotted as a function of /B/ on each shell of force, and in the form of contour maps in B, L space. Although interpretation is reserved for a companion paper, it is believed that this data will be useful reference material for scientists investigating the trapped radiation. Author

N65-26562*# Schjeldahl (G. T.) Co., Northfield, Minn.
[CHEMICALLY MILLED ALUMINUM-POLYPROPYLENE LAMINATES AS SUITABLE MATERIALS FOR USE IN COMMUNICATION SATELLITES] Final Report
S. J. Stenlund and George Miller 13 Nov. 1964 74 p
(Contract NAS5-2834)
(NASA-CR-63458) CFSTI: HC $3.00/MF $0.75 CSCL 11I

Chemically milled aluminum-polypropylene laminates were established as suitable materials for use in communication satellites. In laboratory studies copper chloride was found to be the best etchant for thick aluminum and precision milling. Four-mil thick aluminum was chemically milled to 90% open area with little undercutting and excellent line definition. Also, in 50-day simulated space exposure tests it was demonstrated that polypropylene resists degradation more than Mylar and that hot-spot temperatures for poly-propylene will not exceed 15° C. Further, heating methods were developed which reduce shrinkage of aluminum-polypropylene laminates to as low as 2%. E.E.B.

N65-27386*# California Univ., San Diego.
TRAPPED PROTONS OF THE INNER RADIATION BELT
F. Walker Fillius (Ph.D. Thesis—State Univ. of Iowa) Jun. 1965 106 p refs
(Contracts NAS5-1683; NASr-116; Grant NsG-538)

Satellite Relay I has performed a thorough mapping of the energy spectrum and spatial distribution of protons in the inner zone. New intensity maps are presented in this paper for six energy ranges between 1.1 and 63 MeV as of January 1, 1963. With these six distributions and previously published intensities in two more ranges one can construct accurate energy spectra at arbitrarily selected locations throughout most of the inner zone. In any energy range the maximum intensity is found at the equator, and varies along a line of force near the equator as the third or fourth power of 1/B. There are fewer high energy than low energy protons, and they are found closer to the earth. Neutron albedo sources, both cosmic ray and solar proton sources, are weaker than required by as much as three orders of magnitude at 1 MeV. Adiabatic breakdown theories are in disagreement with the spatial dependence of the energy spectrum and cannot be controlling factors. Injection and diffusion of solar wind particles is a possible source, but more theoretical work is needed to clarify the expected results. Author

N65-27688*# National Aeronautics and Space Administration. Washington, D. C.

GEODETIC JUNCTION OF FRANCE AND NORTH AFRICA BY SYNCHRONIZED PHOTOGRAPHS TAKEN FROM THE ECHO I SATELLITE [LA JONCTION GEODESIQUE FRANCE AFRIQUE DU NORD PAR PHOTOGRAPHIES SYNCHRONES DU SATELLITE ECHO I]

H. M. Dufour Jun. 1965 17 p Transl. into ENGLISH from the Proc. of the Symp. de Géodésie par Satellites, Inst. Géograph. Natl. (France), Dec. 1964 14 p

(NASA-TT-F-9388) CFSTI: HC $1.00/MF $0.50 CSCL 08E

General characteristics of the France-North African geodetic junction groundworks, instrumentation used, preparation for observations, plate processing, and computation programs are described. About sixty positions of the Echo I satellite were selected to be photographed, and the successful photos are tabulated. The problem was to interpolate the position of flashes from the satellite. Theoretical star coordinates on the photographic plate were calculated, and the plates were observed with a comparator. Calculations were made for formulas giving the directing cosines of the flashes in the terrestrial cartesian system, for unknown coordinates of the stations starting from known coordinates, and for intersection of the flashes starting from the approximate coordinates of the stations. L.S.

N65-28467*# National Aeronautics and Space Administration, Washington, D. C.

PROJECT SYNCOM

[1965] 8 p Supersedes NASA Facts-C-5-63

(NASA Facts, Vol. II, No. 14; NASA Facts-C-5-63')

A NASA fact sheet on the Syncom synchronous communications satellite is presented. The ground support, orbiting sequence, spacecraft description, and mode of operation is discussed, and a photograph of Syncom with major components labeled is given. Also included is a facts and figures table for the Relay, Telstar, and Syncom satellites. L.S.

N65-28801# Rome Air Development Center, Griffiss AFB, N. Y. Communications Research Branch.

DATA ANALYSIS OF ECHO I, II, AND THE MOON. VOLUME II: POWER SPECTRAL DENSITY ANALYSIS OF PASSIVE SATELLITE REFLECTED SIGNALS

S. L. Zolnay May 1965 60 p refs

(RADC-TR-65-67, Vol. II; AD-466026)

This report deals with the power spectral density of passive satellite (Echo I, Echo II, and Moon) reflected signals. The prime objective is to present the power spectral density curves of pulsed cw and cw-type signals reflected by Echo II during selected passes of its first 2000 revolutions. Comparisons are made between the spectra of various types of signals reflected by the same satellite; between the spectrum of the same signal reflected by the various satellites; and between the spectrum of the same signal reflected by the same satellite in various path geometries. The conclusions are based on the available data and show that the spectrum of a signal reflected by Echo I differs only negligibly from that of Echo II, while the moon data exhibit details ascribable to considerably more surface roughness than either artificial satellite. The spectrum from Echo II indicate that possible deterioration is resulting in increased surface roughness of the satellite and that the path geometry possibly influences the data. Author

N65-28856*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

TELEVISION TESTS WITH THE SYNCOM II SYNCHRONOUS COMMUNICATIONS SATELLITE

Varice F. Henry and Michael E. Mc Donald Washington, NASA, Jul. 1965 20 p refs

(NASA-TN-D-2911) CFSTI: HC $1.00/MF $0.50 CSCL 17B

The results of a series of experimental tests employing a reduced video bandwidth of 2.5 Mc with the restricted radio frequency bandwidth of 5 Mc in the Syncom II satellite are described. These tests were designed to explore the feasibility of television transmissions for demonstration purposes only because the original system design parameters were based on a few channels of voice transmissions. Emphasis is placed on the microwave parameters of the transmitting and receiving ground terminals, located at Ft. Dix, New Jersey and Andover, Maine respectively. Quantitative and qualitative evaluations of the results are presented, as well as recorded samples of the received video signals which represent the first successful transmissions of standard monochrome television signals in real-time through a synchronous satellite. Author

N65-29009# Goodyear Aerospace Corp., Akron, Ohio.

RICE/WILBERFORCE GRAVITY-GRADIENT DAMPING SYSTEM

A. C. Buxton, D. E. Campbell, and K. Losch 3 Nov. 1964 38 p refs Presented at the ECCANE of the IEEE, Baltimore, 21–23 Oct. 1964

(GER-11749, Rev. A)

The concept and performance of the gravity-gradient damper for application to the NASA Langley lenticular communication satellite are presented. This damper is somewhat similar to the lossy hysteresis spring damper; however, this device is a viscous-fluid damper that exploits resonant rises and the cross-coupling in a helical spring between the plunging and torsional modes, thereby achieving a high-articulation gain that converts the low angular rates of gravity-gradient librations into relatively high rates of rotation in the viscous damper. Thus, the usual limitation of performance of rate-sensitive damping devices in gravity-gradient systems is removed. The damper provides damping about all three axes. For the large-inertia lenticular satellite, the settling-time constants of the transient librations would be about three orbits in pitch and six in roll. Steady-state forced librations of the satellite and damper would be less than 2° E.E.B.

N65-29797# Lockheed Missiles and Space Co., Sunnyvale, Calif.

SYNCHRONOUS OBSERVATIONS OF THE "ECHO-1" FOR GEODESIC PURPOSES

D. E. Shchegolev, A. G. Masevich, and B. G. Afanas'ev [1964] 5 p ref Transl. into ENGLISH from Vestn. Akad. Nauk SSSR (Moscow), no. 7, 1964 p 74–77

The method of cosmic triangulation by synchronous observations of bright artificial earth satellites such as Echo I can be used for solving problems in higher geodesy, including the geodetic foundation of electrophotographic surveys in inaccessible areas, the determination of coordinates of individual objects in Antarctica, and the connections between islands an continents. Cosmic triangulation makes use of simultaneous observations from two or more stations, and all stations take their photographs according to a specified program and at definite time intervals. The track of Echo I appears on a negative as a chain of points, and images of stars are obtained to permit determination of visible equatorial coordinates of the satellite. It is reported that reliable cosmic triangulation is obtained for distances between 3000 and 4000 kilometers, and that synchronized observations have been obtained when the stations were separated by more than 5000 kilometers. M.W.R.

N65-29800*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ENVIRONMENTAL TEST PROGRAM AND SYSTEM EVALUATION OF THE SYNCOM COMMUNICATION SATELLITE
Joseph F. Stockel Mar. 1965 46 p
(NASA-TM-X-55246; X-326-65-98) CFSTI: HC $2.00/MF $0.50 CSCL 22B

A plan is presented for defining test requirements, methods, and general procedures to be followed in testing the prototype and flight models of the Syncom communications satellite. Environmental tests and detailed system performance tests were conducted to evaluate the spacecraft design and operation, with the spacecraft subjected to the system performance tests before and after each environmental exposure. A test sequence is given for each prototype and flight model tested. Motor firing tests were conducted to collect vibration and thermal data by firing the motor aboard an operating spacecraft in a simulated environment. A test was also performed to determine the effects of an explosion of a nitrogen tank on board Syncom I spacecraft; results show that the spacecraft would be silenced. A test log and performance review is given for all systems evaluated. M.R.W.

N65-29805*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
A MUTUAL VISIBILITY COMPUTER PROGRAM FOR COMMUNICATION SATELLITES
G. D. Repass and R. G. Chaplick May 1965 114 p ref
(NASA-TM-X-55271; X-547-65-222) CFSTI: HC $4.00/MF $0.75 CSCL 09B

A Mutual Visibility Computer Program for communication satellites is described for settling problems of scheduling satellite experiments. The program is described as an orbit generator with associated subroutines necessary to perform needed calculations. A brief explanation of how the orbit generator has been programed is given. The computer program is written in Fortran II for the IBM 7094 and is designed typically as a main program with subroutines called when needed. The orbit generator has been designed to compute in one subroutine all quantities which are functions of mean elements and earth constants. Another subroutine computes only those quantities which are either explicit or implicit functions of time. Terms that occur at least twice in the equations are assigned a variable name and actually are computed only once. The results of Main Program One are presented. N.E.A.

N65-29833# Academy of Sciences (USSR), Moscow. Astronomical Council.
OPTICAL OBSERVATION STATIONS FOR ARTIFICIAL EARTH SATELLITES, BULLETIN NO. 36 [STANTSII OPTICHESKOGO NABLYUDENIYA ISKUSSTVENNYKH SPUTNIKOV ZEMLI, BYULLETEN' NO. 36]
1963 36 p refs In RUSSIAN; ENGLISH summary

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1. AT TWO POINTS CONFORMAL ORTHODROMIC PROJECTION FOR LOCATION OF SUBSATELLITE-BIAZIMUT-CHART Gy. Erdi-Krausz p 3-7 refs (See N65-29834 18-30)
2. A SATELLITE PLANISPHERE R. Janichek p 8-13 (See N65-29835 18-30)
3. AN ANALYSIS OF THE STABILITY OF A STATIONARY MOUNTED "TZK" TUBE V. I. Kuryshev p 14-21 refs (See N65-29836 18-14)
4. SYNCHRONIZED OBSERVATIONS OF THE ARTIFICIAL EARTH SATELLITE ECHO-1 IN 1963 D. E. Snebolev p 21-22 ref (See N65-29837 18-30)
5. ON THE BRIGHTNESS VARIATION OF THE SATELLITE "ECHO-1" M. V. Bratiitchuk and G. V. Moskalova p 23-29 refs (See N65-29838 18-30)

N65-29837 Academy of Sciences (USSR), Moscow. Astronomical Council.
SYNCHRONOUS OBSERVATIONS OF THE ARTIFICIAL EARTH SATELLITE ECHO-1 IN 1963 [SINKHRONNYE NABLYUDENIYA SPUTNIKA EKHO-1 V 1963 GODU]
D. E. Shebolev *In its* Opt. Observation Sta. for Artificial Earth Satellites, Bull. No. 36 1963 p 21-22 ref (See N65-29833 18-30)

Discussed are plans to synchronize observations of the artificial satellite Echo-1 during May and June of 1963, which were initiated at the November 1962 meeting of the Soviet Academy of Sciences. Participating were stations located in middle and eastern Europe which were engaged in the photographic observation of artificial earth satellites. More than 1000 synchronous negatives were obtained as a result of this program. Included is a general discussion of the geographical locations of the participating stations. Transl. by S.C.W.

N65-29838 Academy of Sciences (USSR), Moscow. Astronomical Council.
ON THE BRIGHTNESS VARIATION OF THE SATELLITE "ECHO-1" [YESHCHO RAZ OB IZMENENII BLESKA SPUTNIKA "EKHO-1"]
M. V. Bratiitchuk and G. V. Moskalova *In its* Opt. Observation Sta. for Artificial Earth Satellites, Bull. No. 36 1963 p 23-29 refs (See N65-29833 18-30)

Photographically obtained photometric curves of the artificial earth satellite Echo-1 are presented. Discovered was a brief period of the brightness variation of Echo-1. An attempt is made to explain this phenomenon on the basis of the reflecting surface of the object. S.C.W.

N65-30186*# Sea-Space Systems, Inc., Torrance, Calif.
ULTRA THIN GAUGE POLYMERIC FILMS FOR SPACE APPLICATIONS
Dale W. Cox, Jr. Washington, NASA, Aug. 1965 47 p refs (Contract NAS7-274)
(NASA-CR-274) CFSTI: HC $2.00/MF $0.50 CSCL 13H

Experimental resins and a vertical, blown film process, including a conventional long barrel extruder, variable orifice die, and high tower takeup were used to extrude layflat tubular polyethylene film in gauges down to 1/16.3 mil. In this process, molecular orientation was achieved in both the machine and transverse directions, the relative degree depending primarily on the die opening to film gauge ratio and the blow-up ratio. The results were films with approximately balanced

strengths in both directions, with good physical properties and sealability. The ultimate tensile strength of the film was 7500 psi, an increase of almost 300% over conventional gauge film from the same resin. C.T.C.

N65-30349# Ohio State Univ. Research Foundation, Columbus. Antenna Lab.
DATA ANALYSIS OF ECHO I, II AND THE MOON. VOLUME I: AN ANALYSIS OF ECHO II, REFLECTED SIGNALS AT 2 KMC/SEC
S. L. Zolnay Griffiss AFB, N. Y., RADC, May 1965 45 p refs (Contract AF 30(602)-2166)
(RADC-TR-65-67, Vol. 1; AD-617536)

This report discusses the results of the data analysis performed on the data obtained from the Echo satellites and the moon. This volume discusses the general signal characteristics and the accuracy of the system used to collect the data. Author

N65-30366* Pacific Oceanographic Group, Manaimo (British Columbia).
THE POSSIBLE USE OF SATELLITE DATA IN ESTIMATING THE DEPTH OF THE THERMOCLINE
John P. Tully *In* Woods Hole Oceanog. Inst. Oceanog. from Space Apr. 1965 p 153-157 refs (See N65-30350 19-13) CFSTI: HC $7.45/MF $2.25

The use of satellite data in conjunction with existing data or techniques now under development is considered for possible use in estimating the depth of the thermocline. The role of satellites in oceanography, sea surface temperature determination, weather assessment, and communications is discussed. It is considered practical to use drifting sensing buoys, located and monitored by polar orbiting satellites, in any part of the world ocean in spite of limitations of communications facilities. M.W.R.

N65-30511# Ohio State Univ. Research Foundation, Columbus. Antenna Lab.
DATA ANALYSIS OF ECHO I, II AND THE MOON. VOLUME III: THE SURFACE ROUGHNESS OF ECHO II, ECHO I, AND THE MOON AS OBTAINED FROM AMPLITUDE STATISTICS
J. W. Eberle Griffiss AFB, N. Y., RADC, May 1965 28 p refs (Contract AF 30(602)-2166)
(RADC-TR-65-67, Vol. III; AD-617537)

The first amplitude probability density functions of signals reflected from Echo II, Echo I and the Moon are compared. From the density functions for Echo II, the ratio of specular power (correlated) to scattered power (uncorrelated) and the range of fading are obtained, from which the behavior of the surface characteristics are obtained as a function of time during the first four months in orbit. Author

N65-30800# Ohio State Univ. Research Foundation, Columbus.
DETAILED DATA ANALYSIS OF ECHO I, ECHO II AND MOON REFLECTED SIGNALS. VOLUME I: THE SIGNAL TO NOISE RATIO IMPROVEMENT IN ADAPTIVELY PHASED ARRAYS Interim Report, Jan.–Sep. 1964
S. L. Zolnay and J. W. Eberle Griffiss AFB, N. Y., RADC, May 1965 27 p refs
(Contract AF 30(602)-2166)
(RADC-TR-65-68, Vol. 1; AD-616535)

This report presents the results of a detailed analysis of data collected from January through September 1964 using Echo I, Echo II, and the moon as reflectors of S-band signals. Information is presented, in four volumes, signal-to-noise ratio improvements in adaptively phased arrays and the autocorrelation function of signals reflected from Echo II. Author

N65-30863# Ohio State Univ. Research Foundation, Columbus.
DETAILED DATA ANALYSIS OF ECHO I, ECHO II AND MOON REFLECTED SIGNALS. VOLUME 4: THE LONG-TERM AUTOCORRELATION FUNCTION OF ECHO II REFLECTED SIGNALS
S. L. Zolnay and J. W. Eberle Griffiss AFB, N. Y., RADC, May 1965 8 p ref
(RADC-TR-65-68, Vol. 4; AD-616534)

It is concluded that Echo II is apparently rotating in its orbit with a period between 90 and 95 seconds and that the ratio of extreme radii of curvature is 1.03, representing essentially a spherical reflector for the aspect angles involved in the measurement. Author

N65-31263# Argentine National Commission on Space Research, Buenos Aires.
INTERAMERICAN SYMPOSIUM ON SPACE RESEARCH, PROCEEDINGS, VOLUME I [SIMPOSIO INTERAMERICANO DE INVESTIGACIONES ESPACIALES, TRABAJOS PRESENTADOS, VOLUMEN I] Special Publication No. 3
1965. 87 p refs Symp. Held at Buenos Aires, Aug. 1964 (CNIE-PE-3)

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1. THE GLOBAL COMMERCIAL COMMUNICATIONS SATELLITE SYSTEM—AN UP-TO-DATE SUMMARY AND REVIEW E. J. Istvan 6 p (See N65-31264 20-07)
2. HASP-A FAMILY OF U. S. NAVY METEOROLOGICAL ROCKETS M. J. Parker 20 p (See N65-31265 20-31)
3. THE THERMAL SIMULATION OF SPACE R. W. Porter, M. W. Mitchell, and F. O. Drummond 29 p refs (See N65-31266 20-30)
4. NASA SPACE ELECTRONICS RESEARCH G. A. Vacca 27 p (See N65-31267 20-10)

N65-31264 Communication Satellite Corp., Washington, D. C.
THE GLOBAL COMMERCIAL COMMUNICATIONS SATELLITE SYSTEM—AN UP-TO-DATE SUMMARY AND REVIEW
Edwin J. Istvan *In* Arg. Natl. Comm. on Space Res. Interam. Symp. on Space Res., Proc., Vol. 1 1965 6 p (See N65-31263 20-30)

The current status of the program for the global commercial communications satellite system is reviewed. The establishment of international arrangements for the use of the satellite, the technical feasibility and economic viability of establishing and operating the system, the technical timetable for full global communications coverage, international financing and ownership of the satellite and earth stations, and provisions for satellite use by non-investors are discussed. R.N.A.

N65-31512# Naval Research Lab., Washington, D. C.
RECEPTION VIA THE SYNCOM II COMMUNICATION SATELLITE USING AN 8-FOOT PARABOLIC ANTENNA
W. E. Leavitt and J. P. Spraitz 17 May 1965 19 p refs
(NRL-MEMO-1617; AD-617557)

Signals transmitted by the U.S. Army Satellite Communication Agency's (USASCA's) Camp Roberts terminal via Earth satellite SYNCOM II were received at the Naval Research Laboratory (NRL) using an eight-foot diameter parabolic antenna feeding into a parametric amplifier. The antenna system configuration provided performance capability equivalent to a 5.7-foot diameter parabolic antenna with 237° K (Kelvin) noise temperature. Phase lock frequency modulation (fm) detection circuitry was used for demodulation of the received signal. Voice reproduction was slightly distorted when the satellite was operating in the simplex mode with the Camp Roberts transmitter adjusted for 200 watts input to its 60-foot antenna (radiation efficiency—55%). Received signal strength was found to be in agreement with predicted values. Author

N65-31687# Rome Air Development Center, Griffiss AFB, N. Y.
RADC TRINIDAD-ROME SATELLITE COMMUNICATION LINK Final Report
Rodney C. Pratt Jun. 1965 47 p refs
(RADC-TR-65-217; AD-466002)

This report describes the facilities at Rome and Trinidad which are used to perform communication experiments using the Echo type satellites. These facilities have undergone many modifications over the past five years and this report describes the facility as it presently exists. The Rome and Trinidad facilities provide a duplex communication link when used with passive satellites. The communication for this link is accomplished at S band while tracking at Trinidad is dependent upon a 427 mc radar set. There have been some unique developments in providing this capability with work continuing on a high power dual frequency feed. The Trinidad facility will be closed down by 30 June 1965 but the Floyd facility will be retained for future work. Author

N65-31891# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Techonology Div.
THE COMMUNICATIONS SATELLITE
Mo King and Fan Ping 7 Jul. 1965 10 p Transl. into ENGLISH from Kexue Dazhone (China), no. 7, 1963 p 6-7, 21
(FTD-TT-64-961/1+2+3+4; AD-466525)

Economic significance, practical considerations, and technical possibilities of communications satellites are discussed in general terms. Considered are relay stations in outer space; and passive reflecting, active communications, synchronous communications, and low orbit satellites. Three modes of electromagnetic wave transmission are illustrated; and a world-wide communications system formed by three synchronous satellites in orbits at an altitude of 35 800 kilometers is discussed and illustrated. Since it is difficult to launch satellites at this high altitude, the use of a larger number of satellites in orbit closer to the earth is considered. M.W.R.

N65-32054# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
SYNCHRONOUS OBSERVATIONS OF MAN-MADE EARTH SATELLITE ECHO-1 FOR GEODETIC PURPOSES
D. Ye. Shchegolev, A. G. Masevich, and B. G. Afanas'yev 30 Jun. 1965 11 p Transl. into ENGLISH from Vestn. Akad. Nauk SSSR (Moscow), no. 7, 1964 p 74-77
(FTD-TT-65-313/1+2+4; AD-617676)

The principle of geodetic triangulation using satellites is discussed. The method of cosmic triangulation by synchronous observations of Earth satellites appears to offer unique opportunities of obtaining electrophotographic representations of inaccessible regions of the earth. Also, the method opens broad possibilities for international cooperation in defining the coordinates of islands and other points of importance for sea navigation. E.E.B.

N65-32119*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
A DETERMINATION OF EARTH EQUATORIAL ELLIPTICITY FROM SEVEN MONTHS OF SYNCOM II LONGITUDE DRIFT
C. A. Wagner [1964] 5 p refs Submitted for Publication
(NASA-TM-X-54802) CFSTI: HC $1.00/MF $0.50 CSCL 08E

From observations of the 24-hour Syncom II satellite it is shown that J_{22} (adjusted for probable higher order earth gravity effects) = $-(1.9 \pm 0.2) \times 10^{-6}$ where J_{22} is the amplitude of the first significant longitude dependent term in the spherical harmonic expansion of the earth gravity potential. It is related to the difference between major and minor earth equatorial radii by $a_0 - b_0 = -6R_0J_{22}$ where R_0 is the mean equatorial radius of the earth and a_0 is the semi-major axis of the 24-hour satellite. It is also shown that $a_0 - b_0 = 73 \pm 8$ meters which is the difference in major and minor equatorial radii at $21 \pm 7°$ west of Greenwich. Unless the earth is far more inhomogeneous than is thought to date, these estimates can be considered the absolute bounds of the ellipticity of the equator. E.E.B.

N65-32187*# International Business Machines Corp., Rockville, Md. Federal Systems Div.
SPACE COMMUNICATIONS THEORY AND APPLICATIONS. VOLUME 4: SATELLITE AND DEEP SPACE APPLICATIONS A Bibliography
Richard F. Filipowsky and Louise C. Bickford, comp. Washington, NASA, Jul. 1965 303 p refs
(Contract NASw-981)
(NASA-SP-7022(04), Vol. 4) GPO: HC $1.75; CFSTI: MF $1.75 CSCL 17B

An annotated bibliography is presented covering communications satellites, instrumented satellites, deep space flight, and manned space flight with emphasis on the communications equipment and technology. The references relate to publications of a predominantly systems character. Hardware oriented publications have been, to a large degree, excluded to keep the bibliography within specified limits. E.E.B.

N65-32761# Joint Publications Research Service, Washington, D. C.
STRUCTURE OF THE D-1 SATELLITE
1 Sep. 1965 8 p Transl. into ENGLISH from Air et Cosmos (Paris), no. 114, 17 Jul. 1965 p 14-15, 46
(JPRS-31798; TT-65-32293) CFSTI: $1.00

Described is the structure and instrumentation of a proposed lightweight French satellite that will use honeycomb material structures to achieve minimum weight for a given degree of strength. This satellite will be used in telemetering and remote control of the Diane and Iris radar networks; for orbital calculations from interferometric and Doppler data; for testing of an ultra-stable oscillator; and to obtain information on the behavior of the most important systems and operations on board of the rocket during space flight. G.G.

N65-33805*# National Aeronautics and Space Administration, Washington, D. C.
RECENT DEVELOPMENT AND PERSPECTIVES OF COMMUNICATIONS SATELLITES [EVOLUTION RECENTE ET PERSPECTIVES DES SATELLITES DE TELECOMMUNICATIONS]
V. A. Altovsky Sep. 1965 44 p Transl. into ENGLISH from FRENCH Presented at the 5th European Space Symp., Munich, Jul. 1965
(NASA-TT-F-9555) CFSTI: HC $2.00/MF $0.50 CSCL 22B

A review of existing communications satellites, including TELSTAR, RELAY, SYNCOM, EARLY BIRD, MOLNYA, etc., with tabulated data on worldwide coverage of the systems, main characteristics, and orbital aspects, is followed by a brief discussion of European projects and future participation in US projects. Advantages of phased and clustered systems are compared, and European preference for 24-hour orbit systems is emphasized. A French project of a three-orbit system with groups of 4-5 satellites each and a 12-hour circular orbit at 20 400 km is described briefly. Author

N65-35393*# National Aeronautics and Space Administration, Washington, D. C.
GROUND STATION COMMITTEE, CAPE KENNEDY, 1-2 DECEMBER 1964
Jan. 1965 4 p Transl. into ENGLISH from Compte Rendu de France Concernant la Station Terrienne de Pleumeur-Bodou, Centre Natl. d'Etudes des Telecommun. (France), p 1-3
(NASA-TT-F-9241) CFSTI: HC $1.00/MF $0.50 CSCL 22D

The article examines present operation and accomplishments by the Pleumeur-Bodou tracking station with the Relay and Telstar series of satellites. Technical changes now being undertaken, and projects for expanded future operation are outlined. Author

N65-35703# Ohio State Univ., Columbus.
DETAILED DATA ANALYSIS OF ECHO I, ECHO II, AND MOON REFLECTED SIGNALS. VOLUME 2: AUTOCORRELATION FUNCTIONS OF ECHO II REFLECTED SIGNALS
J. W. Eberle and S. L. Zolnay Griffiss AFB, N. Y., RADC, May 1965 35 p refs
(Contract AF 30(602)-2166)
(RADC-TR-65-68, Vol. 2; AD-616532)

Short-term autocorrelation function of Echo II passive satellite reflected signals are investigated. Sample signal lengths were 30 seconds; maximum time delays were in the order of three seconds. Autocorrelation functions were obtained from pulsed and cw signals, at sampling rates of 29, 50, and 100 per second during different revolutions and with the satellite in various path geometries. Adaptation of the autocorrelation function computations to digital techniques is considered, and two methods of linearizing obtained data are presented. An expression is derived for the specular-to-spattered power ratio, and the inverse transform of the function is considered. Qualitative analysis is made of the Fourier transform. Surface roughness of the reflector, discrete fading rates, and fading frequencies are discussed. M.W.R.

N65-35950*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
MEMBRANE ANALYSIS OF PRESSURIZED THIN SPHEROID SHELLS COMPOSED OF FLAT GORES, AND ITS APPLICATION TO ECHO II
Hossein Bahiman Washington, NASA, Oct. 1965 13 p refs
(NASA-TN-D-3002) CFSTI: HC $1.00/MF $0.50 CSCL 20K

Membrane analysis of very thin pressurized spheroid shells composed of flat gores led to a set of nonlinear differential equations for three membrane displacements. An approximate solution by the perturbation technique is established. As an example, the approximate shape of Echo II is computed.
Author

1966
STAR ENTRIES

N66-10134 Polish Academy of Sciences, Warsaw. Poznan Astronomical Observatory.
PHOTOGRAPHIC OBSERVATIONS AT STATION NO. 1154 IN POZNAN
Hieronim Hurnik *In its* Artificial Earth Satellites 1965 p 19–23 (See N66-10130 01-30) CFSTI: HC $4.00/MF $1.00

The general astrometric character of the work of the Observatory and the observations of the Echo satellites for the purpose of satellite triangulation are discussed. Also, the development of a special photographic camera with automatic registration is described in detail. E.E.B.

N66-10226*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
RELAY I PROGRAM Final Report
Washington, NASA, 1965 749 p refs
(NASA-SP-76) GPO: HC $4.25; CFSTI: MF $3.50 CSCL 22B

Relay I program papers are presented on the overall Relay system, operational problems, and international ground stations. For individual titles see N66-10227–N66-10261.

N66-10227* Space Technology Labs., Inc., Redondo Beach, Calif.
THE RELAY SYSTEM
B. N. Abramson, W. Littenberg, M. R. Skinner, and C. M. Thomas *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 5–19 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1302)

System design tradeoffs, spacecraft specifications, and orbit characteristics are summarized for the Relay I program. Ground and test station design characteristics are considered in terms of frequency selection and necessary power levels; communication system characteristics and performance objectives are discussed; and communication link performance margins between the various stations are evaluated. Power budgets for transmission of television and telephony between two stations are tabulated, and system performance for these transmissions is listed. A map shows the location of the seven ground and test stations are tabulated. The antenna and receiver are described for each, along with transmitting and receiving capabilities, gain at 1725 and 4170 Me, and total system noise temperature at 7.5° elevation. M.W.R.

N66-10228* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE RELAY SPACECRAFT
P. H. Pickard *In its* Relay I Program 1965 p 21–27 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50

Structure, power, communications, telemetry, tracking, and command are discussed for the Relay I spacecraft; a cutaway drawing shows the positions of the various components. Two completely independent microwave repeaters, with a common antenna, are provided to increase spacecraft reliability. The satellite transmitter output power of 10 watts gives a margin of at least 6db for TV transmission over a maximum slant range of 5000 nautical miles. The receiver is completely solid state; the microwave antenna consists of a coaxial receiving antenna above a coaxial transmitting antenna, both contained in one mechanical assembly. Both wideband and narrowband modes of operation can be used with the transponder. In addition to the subsystems required to support the principal mission of Relay, the spacecraft contains six radiation detectors and a number of isolated solar cells and semiconductor diodes to obtain data on particle radiation in space. M.W.R.

N66-10229* Radio Corp. of America, Princeton, N. J.
STRUCTURAL AND DYNAMIC CONSIDERATIONS IN THE SPACECRAFT DESIGN
C. C. Osgood and G. D. Gordon *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 29–62 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1272)

Configuration specifications, load analysis, structural design, and weight considerations are detailed for the Relay I spacecraft. A plot of inertia ratio versus solar cell area was made to determine the limiting values for the necessary design parameters; and allowable dynamic unbalance for various configurations was determined. A counter torquing system was designed to overcome the errors which result from magnetic torques; counter torque produced by current flow through the coil adjusts the spin axis attitude approximately one degree each day. Spacecraft attitude is determined by a solar aspect indicator and an Earth horizon scanner; the angular information obtained is used to calculate the amount and direction of correctional torque and to program the proper commands. Since this method of attitude control requires the residual magnetic dipole moment in the spacecraft to be zero, a compensating magnet is introduced. Requirements for structural materials, methods of fabrication, and coulomb damper design are considered. Basic spacecraft thermal design and the various spacecraft components are described. M.W.R.

N66-10230* Space Technology Labs., Inc., Redondo Beach, Calif.
SPACECRAFT PERFORMANCE
D. E. Kendall *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 63–90 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1302)

Observed performance of the Relay I spacecraft is detailed and compared with prelaunch and expected results; and spacecraft temperature history, orientation, and spin rate characteristics are discussed. Electrical power system performance data deal with transponder no. 1 failure, load verification, and solar array performance. With the exception of the failure of the no. 2 charge controller, adequate battery performance was observed. Numerous graphs detail aspects of battery performance, including improvement after low voltage cutoff, discharge curves before and after continuous trickle mode, characteristics before and after deep discharge, and accumulated transponder no. 2 operating time compared with eclipse history. Electrical performance specifications are tabulated, and wideband receiver and transmitter block diagrams are included. Data for the traveling wave tube indicate that TWT characteristics remained essentially constant during the operational lifetime of Relay I. M.W.R.

N66-10231* Radio Corp. of America, Princeton, N. J.
THE MICROWAVE REPEATER
J. Kiesling, H. R. Mathwick, T. Wakefield, W. Wilkinson, and I. E. Podraczky *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 91–127 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1272)

A dual-mode, active heterodyne repeater was designed and successfully tested in connection with Project Relay, which was concerned with providing a high quality communications link to experimentally verify the feasibility of microwave communications via an active spacecraft repeater. Repeater function and the basic design configurations are discussed, and a summary of performance requirements is tabulated. Details are presented for the microwave antenna and receivers. Basic requirements, major characteristics, and environmental considerations for the traveling wave tube are discussed. Fabrication procedures are given and the test program is presented for the TWT; the effect of refocusing during aging on helix current is shown; and the TWT power supply parameters are given. The repeater was swept in frequency in both wideband and narrowband modes to insure that receiver bandpass characteristics were adequate and not a function of signal level. The largest spurious output in both modes was observed at 4193 Mc and was 36 db below the carrier. This is the 37th harmonic of the beacon crystal frequency. M.W.R.

N66-10232* Radio Corp. of America, Princeton, N. J.
THE TELEMETRY SYSTEM
E. Mozzi and S. Roth *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 129–152 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1272)

Design and operation are considered for the signal conditioner, telemetry encoder, telemetry transmitter, and antenna for the Relay I telemetry system. Relay I telemetry channel allocations are tabulated and performance characteristics and reliability are discussed for the encoder which uses solid state circuitry. The development program, flight model program, and system for the transmitter is presented; and sensitivity of the transmitter was reduced to provide a compatible system. Maximum frequency variations for Project Relay telemetry transmitters are tabulated. Design requirements, problems encountered, and a performance evaluation are included for the TT&C (two transmitters and a 3-db coupler) antenna system. M.W.R.

N66-10233* Radio Corp. of America, Princeton, N. J.
THE COMMAND SYSTEM
S. Roth, H. Goldberg, and J. Blair *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 153–169 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1272)

Ground transmitted commands and internal logic functions are described for the Relay I command system. The 20 direct commands and their respective control circuit outputs are tabulated; three of the commands each require the accomplishment of two functions. The command receiver, which is required to receive, amplify, and demodulate coded ground station instructions, is discussed in terms of design approach, parameters, packaging, and environmental testing. Command demodulator and decoder equipment was developed to demodulate the tone bursts which contained the coded messages, convert the pulse-duration modulation into a binary code, and decode the messages into the twenty discrete commands required for command system functioning. The control box input channels and other signals are described, and packaging and testing are mentioned. M.W.R.

N66-10234* Radio Corp. of America, Princeton, N. J.
THE SPACECRAFT POWER SUPPLY SYSTEM
T. R. Wylie, P. J. Callen, G. Zielinski, E. Holloway, L. Pessin et al *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 171–189 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1272)

The solar-array, storage battery power supply system for the Relay I spacecraft was designed to permit a minimum of 100 minutes of microwave communication per day. Silicon solar cells converted solar rays to electrical energy while the spacecraft was illuminated; a nickel-cadmium storage battery supplied power during eclipse periods. Battery power could also be used to supplement solar power when necessary. The solar panel substrate is pictured and discussed; array arrangement and array power output are considered; and the storage battery's capacity and charge controller are detailed. Electrical test data are given for the high power and low power voltage regulators; and the voltage limiter, which is a shunt regulator that provides protection for all circuitry connected to the solar bus, is considered. The one-year timer, an electrochemical device to open the solar array bus and thus deactivate the spacecraft after one year in orbit, is powered by a 9-volt zener supply, and weighs 0.3 lb. M.W.R.

N66-10235* Radio Corp. of America, Princeton, N. J.
SPACECRAFT ENVIRONMENTAL TESTING
W. Schreiner, R. Newman, M. Gittler, and S. Rummel *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 191–205 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1272)

Physical tests were performed on Relay I to approximate the environment and stress which would occur during handling, launch, and orbital flight. Temperature, humidity, vibration, shock, pressure, sand and dust, salt spray, fungus, solar radiation, and rain are discussed in terms of long-term earth events. Aerodynamic and propulsion sources of temperature, vibration, acoustic noise, shock, spin, acceleration, and vacuum conditions are considered for events associated with the spacecraft launching. Temperature, vacuum, charged particle radiation, and micrometeroids are the factors of concern during orbital flight. The various qualifications tests performed include spin, temperature, vibration, solar simulation, humidity, thermal gradient, and steady state acceleration. Acceptance tests were made for spin, temperature, solar simulation, and vibration; and the vibration acceptance test inputs are tabulated. M.W.R.

N66-10236* Radio Corp. of America, Princeton, N. J.
GROUND SUPPORT EQUIPMENT
W. Schreiner, R. Newman, and M. Gittler *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 207-225 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1272)

Spacecraft checkout equipment, environmental simulation facilities, and handling fixtures made up the ground support equipment for Relay I; microwave repeater checkout provides for transmission and reception of video test signals to determine differential phase, differential gain, and low and high frequency characteristics. Since much of the Relay testing was concerned with reduction of telemetry data, a relatively complete telemetry decommutation station was used for the checkout studies. A pulse synchronizer, test generator, word sync and recognition unit, analog and digital word selectors, and a binary decimal converter were used in the telemetry studies. Command checkout equipment is also discussed. A solar simulator, which approximates duplicate incident solar energy flux and spectral energy distributions, utilized two 13.6 mm high-intensity carbon arc lamps. System layout is shown and output measurements are discussed. Handling procedures and fixtures for the Relay spacecraft are concerned with vertical and horizontal lifting fixtures, work stand, bird cage, and shipping container. M.W.R.

N66-10337*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A FREQUENCY INDEPENDENT TECHNIQUE FOR EXTRACTING THE RIGID-BODY MOTION FROM THE TOTAL MOTION OF A LARGE FLEXIBLE LAUNCH VEHICLE
James C. Howard Washington, NASA, Nov. 1965 57 p refs (NASA-TN-D-3109) CFSTI: HC $3.00/MF $0.50 CSCL 20K

A method was devised for extracting rigid-body motion from the total motion of a flexible body. This method, which does not rely on the relative frequencies of the closed-loop rigid-body control mode and the elastic modes of conventional filters, is well adapted to situations where a flexible-body frequency coincides with, or differs only slightly, from the control mode frequency. It involves the use of processing functions and requires that the number of sensing elements be equal to the number of modes of motions considered. Rejection of spurious flexible-body motion is accomplished by making the processing function associated with each sensing element a prescribed function of the model slopes or the model displacements. When the processing functions are allocated as prescribed, the information reaching an operator's display panel, or the summing junction where error signals are generated, will not be contaminated by flexible-body motion. R.R.D.

N66-10238* Radio Corp. of America, Princeton, N. J.
RELIABILITY PROGRAM
H. F. Wuerffel, R. A. Smith, L. Gomberg, and D. F Metz *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 261-271 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1272)

Component part reliability, system reliability analysis, conservative design, rigorous testing, and quality control provided the basis for the overall reliability program for Relay I. A description is given of the spacecraft mission profile and the parts program. It is emphasized that redundancy was incorporated at all levels of the development program to determine the inherent reliability of the spacecraft. Two separate models and a composite of the two were developed to determine the reliability of three modes of transmission. Malfunction data reporting and analysis were made to determine if the final product had the reliability designed into the circuit and to eliminate problems arising from design, system integration, and testing. In spite of these preliminary tests, the inability to turn off one of the high power regulators and its associated wideband repeater was not discovered until the Relay spacecraft was in orbit. This malfunction was related to excessive reverse leakage current and dew point. Vendor control, preconditioning, product quality control, manufacturing environment and handling, and log books are discussed. M.W.R.

N66-10239* Space Technology Labs., Inc., Redondo Beach, Calif.
THE RELAY EXPERIMENT PLAN
R. Cagnon *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 275-287 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1302)

Wideband, narrowband, multiplex, and one-way noise loading capabilities of ground stations participating in Project Relay are summarized; and the various communications experiments performed are described. Categories for these experiments include: (1) received carrier power and insertion gain, (2) noise measurements, (3) linear distortion, (4) nonlinear distortion, and (5) special transmission tests. Television test patterns provide a basis for subjective evaluation of the TV system performance; and system demonstration tests indicate the feasibility of satellite communications for television, telephony, digital data, teletype, and facsimile transmission. M.W.R.

N66-10240* Space Technology Labs., Inc., Redondo Beach, Calif.
G SFC RELAY COMMUNICATIONS SATELLITE TEST STATION
T. H. Guerin, R. G. Slaughter, and W. C. Wray *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 289-328 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1302)

An overall system description and implementation are considered for the two Relay communications satellite test stations, located at Nutley, N. J., and near Goldstone, Calif. These stations, which are equipped for satellite checkout and for TV transmission and reception, can command control, monitor spacecraft telemetry, and conduct communications experiments at the direction of the Relay Operations Center at Greenbelt, Md. Telemetry, command, wideband communications transmitter, communications receiver, video, frequency-division multiplex telephone, and the antenna and tracking systems are described for the test stations. Test station mobile trailers are shown and various equipment layouts are diagrammed. M.W.R.

N66-10241* Space Technology Labs., Inc., Redondo Beach, Calif.
THE RELAY TEST STATION LOW NOISE RECEIVING AND DEMODULATION SYSTEMS
R. S. Eastman and R. A. Miller, Jr. *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 329-358 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1302)

The wideband FM receiving subsystems in use at the NASA Goddard Relay Test Stations are similar in design except for the antennas. Descriptions are presented of the equipment, with special attention directed to the theory of operation and performance data of the 4 Gc, liquid nitrogen cooled, parametric amplifier and wideband phase-lock demodulator. System noise temperatures of 100°-125° K have been measured in accordance with performance objectives. Threshold improvement of 5 db over that of a conventional discriminator has been demonstrated by the use of the phase-lock demodulator. Author

N66-10242* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
RELAY SYSTEM OPERATIONS
D. E. Kendall (Space Technol. Labs.) and W. S. Sunderlin *In its* Relay I Program 1965 p 359-382 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50

This paper discusses the operational aspects of Relay with respect to the techniques used in operating the spacecraft in orbit and the experience acquired during the in-orbit operation. A description is given of the Relay Operations Center and its functions, including the support communications network of telephone, teletype, and video monitor links that were required for effective control of the satellite and coordination of operations. The requirements for satellite command and for real-time telemetry data reduction and evaluation are outlined, and a description is given of the system used to meet these requirements. Examples are given of how the system was applied to specific operational situations. The operation of the satellite involved the issuance of operational plans that provided for scheduling of communication experiments and of station participation. A discussion is given of the basis for scheduling, such as selection of specific orbit revolutions for stations and experiments on the basis of mutual visibilities, slant ranges, spacecraft look angles, ground antenna elevation angles, eclipses, and spacecraft duty cycle. The effect of precession of the orbit on mutual visibilities is also discussed.
Author

N66-10243* Radio Corp. of America, Princeton, N. J.
SPURIOUS SIGNALS IN SATELLITE COMMAND SYSTEMS
J. C. Blair *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 383-402 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1272)

Problems encountered during operation of the Relay I command system are generalized for a discussion of spurious signals in satellite command systems. An analysis is made of the command system; and the command control box and a list of commands are considered. Error probabilities are computed for the two basic types of command errors in a system such as Relay: (1) failure to effect the desired command and (2) occurrence of commands which are not actually transmitted. Receiver noise density and power calculations are made. Since spurious commands became a serious problem during the orbit of Relay I, a performance analysis of its command system was undertaken. Spurious commands were tallied for the 20 commands given the Relay spacecraft, and various laboratory tests and a command decoder investigation were made. It is emphasized that interfering signals must be considered a basic problem which any command system will encounter. Secure command systems can result from increased complexity in operational procedures; command signal squelching with improper signal recognition is the technique employed in the Relay II program.
M.W.R.

N66-10244* Bell Telephone Labs., Inc., Murray Hill, N. J.
THE ENERGETIC PARTICLE ENVIRONMENT OF RELAY I
W. L. Brown, L. W. Davidson, and L. V. Medford *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 403-427 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1678)

Two semiconductor p-n junction particle detectors are used to evaluate energetic particle environment encountered by the Relay I spacecraft, and to provide information of trapped radiation belts. One of the detectors measures electrons with energies above approximately 1 Mev; the other measures protons in the 2.5 to 8 Mev region. Electron measurements over a seven month period, which correlate well with those made on Explorer XV, are characterized by a stable high intensity inner belt and a relatively unstable outer belt. Flux of low energy protons reaches a single maximum at an equatorial value of L of about 1.9 earth radii for protons of about 5 Mev, and 2.1 earth radii for 2.5 Mev. These low energy protons, which have an extremely high damage rate per particle in semiconductor materials, are responsible for most of the damage sustained by Relay I during experiments with unshielded solar cells. Observed maximum damage rates coincide with periods during which the satellite is in or near the maximum in proton distribution.
M.W.R.

N66-10245* California Univ., La Jolla.
RELAY I TRAPPED RADIATION MEASUREMENTS
C. E. Mc Ilwain, R. W. Fillius, J. Valerio, and A. Dave *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 429-447 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NASr-116)

The spatial dependence of the intensities of geomagnetically trapped electrons with energies greater than 0.45 Mev and of protons in four energy ranges have been measured in the region within radial distances of 1.2 and 2.3 earth radii.
Author

N66-10246* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE RELAY I RADIATION EFFECTS EXPERIMENT
R. C. Waddel *In its* Relay I Program 1965 p 449-468 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50

Solar cells on Relay I were monitored for radiation damage by measurement of short circuit current. The orbit was 1321 km perigee, 7439 km apogee, 47.5 degrees inclination. Unshielded N/P, P/N, and gallium arsenide cells degraded in 10 days to 52%, 28%, and 18%, respectively. This damage is ascribed to low energy protons. At 300 days silicon N/P and P/N cells, shielded with 30 mils of fused silica, degraded to 73% and 53%, respectively. At 300 days silicon N/P and P/N cells, shieded with 60 mils of fused silica, had degraded to 80% and 61%, respectively. Available space flux maps predicted somewhat greater damage to the heavily shielded cells, from either electrons or high energy protons, than that observed. The minority carrier lifetime of some silicon diodes declined to 50% in about 45 days.
Author

N66-10247* Bell Telephone Labs., Inc., Murray Hill, N. J.
THE ANDOVER GROUND STATION
A. Klute *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 469-476 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1987)

To provide means for transmitting and receiving from communications satellites, the Andover, Me. ground station is equipped with communications antenna, transmitting and receiving equipment, coupling circuitry, satellite tracking equipment, and means for programming the antenna to track the visible portion of the satellite's orbit. Descriptions and illustrations are offered for the equipment; and site selection is discussed.
M.W.R.

N66-10248* Bell Telephone Labs., Inc., Murray Hill, N. J.
COMMUNICATIONS EXPERIMENTS CONDUCTED AT ANDOVER, MAINE
R. E. Blatz *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 477-514 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-1987)

Communications tests conducted on the Relay I satellite, based on data taken at the Andover test station, were found to be in good agreement with theoretical values. Many of the tests were conducted on a loop basis, from Andover to the satellite and back to Andover. The ground station communications system is described and diagrammed as is multiplex system equipment. Data and measurements are discussed for received carrier power, baseband transmission, noise, and nonlinearity. Typical photographs of television test patterns are included which were used to evaluate the overall transmission characteristics of the satellite system. Both feedback and standard FM receivers were used. Two-way telephony performance was evaluated with measurements from widely separated stations; and tabulations are presented for insertion gain, baseband loop noise, satellite noise, and intelligible crosstalk. M.W.R.

N66-10249* ITT Federal Labs., Nutley, N. J.
THE NUTLEY GROUND STATION
B. Cooper and R. Mc Clure *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 515-524 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-2056)

An existing space communications research station was modified to meet the requirements of the Relay project, and a description is offered of the six major equipment areas: transmitter, communications receiver, terminal equipment, antenna and tracking system, coordinating facilities, and special test equipment. Major specifications are included for all the internal test equipment located at the ground station, which includes a 10-kw transmitter, a 40-ft paraboloidal antenna with Cassegrainian feed system, and a radio-frequency equipment pod located near the apex of the primary reflector. New equipment designs have been combined in the development of a transportable ground station capable of supporting a medium-capacity satellite system such as Relay. M.W.R.

N66-10250* ITT Federal Labs., Nutley, N. J.
RESULTS OF RELAY I NARROWBAND EXPERIMENTS
In NASA. Goddard Space Flight Center Relay I Program 1965 p 525-545 refs (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50
(Contract NAS5-2056)

Narrowband experiments were performed for Relay I to determine the extent to which a theoretical communications system can meet performance requirements. The twelve experiments undertaken while the spacecraft was in orbit are listed along with the number of times each was performed. For example, received carrier power was tested 645 times; continuous random noise, 141; insertion gain, 70; and intelligible crosstalk, 6. Detailed analyses are included for intermodulation distortion tests, system threshold with and without extension, and spacecraft noise figure in narrowband mode. A near-zenith tracking experiment is also discussed. It is demonstrated that the two-tone harmonic performance test provides a means for separately predicting the contributions of amplitude and phase nonlinearities to noise intermodulation. Measured and calculated values of signal-to-noise ratio are in good agreement; measurement of satellite noise indicates degradation of about 2 db from prelaunch values. M.W.R.

N66-10251* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
GSFC DEMONSTRATIONS
G. Bullock *In its* Relay I Program 1965 p 549-559 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50

Television, facsimile, teletype, voice, and special demonstrations were made by the various ground stations during the flight of Relay I. Photographs are included for some of the demonstrations, and all of the demonstrations performed are tabulated. M.W.R.

N66-10252* Companhia Radio Internacional, Rio de Janeiro (Brazil).
RIO DE JANEIRO SPACE COMMUNICATIONS STATION
J. C. Fonseca and C. H. Moreira *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 561-574 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50

The Rio de Janeiro Space Communication Station is being used to conduct two-way telephone, teletype, and data transoceanic experimental communications by satellite, between North America, Europe, and South America. The Station can handle two-way, 12 simultaneous telephone conversations or 12 teleprinter of high speed data per voice channel, or 144 total circuits whenever speech is not being transmitted. This chapter describes the general station setup, the general design of the equipment, and operational procedures. Author

N66-10254* Centre National d'Etudes des Telecommunications, Issy les Moulineau (France).
RESULTS OF TESTS PERFORMED WITH RELAY I AT THE PLEUMEUR-BODOU SPACE COMMUNICATIONS STATION
L. Bourgeat, A. Dyevre, and J. P. Houssin *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 597-632 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50

A description is given of the tests performed at the French satellite communications station at Pleumeur-Bodou with the Relay I satellite. An analysis is given of the means for acquiring and tracking a satellite and of the characteristics of the resulting communication link. The tests were extremely satisfactory and provided the experience necessary for the commercial exploitation of future satellite communication links. Author

N66-10256* Deutsche Bundespost, Darmstadt (West Germany).
RESULTS OF TESTS PERFORMED WITH RELAY I AT THE RAISTING SPACE COMMUNICATIONS STATION
E. Dietrich et al *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 641-645 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50

Narrowband tests performed with Relay I at the Raisting space communications station in Germany were concerned with insertion gain stability, continuous random noise, amplitude-frequency baseband, intelligible crosstalk, two-way telephony, and teletype and facsimile transmission. Positions of Relay I during the experiments are tabulated as is an evaluation of teletype transmission. M.W.R.

N66-10257* Telespazio, S.p.A., Rome (Italy).
DESCRIPTION AND RESULTS OF TESTS PERFORMED AT FUCINO EARTH STATION WITH RELAY I
P. Fanti et al *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 647-655 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50

Communications and tracking facilities of the Fucino space communications ground station in Italy are described, and results are given for experiments with the Relay I performed there. Received carrier power and narrowband and wideband experiments are reported. Baseband characteristics, continuous random noise, noise loading, harmonic performance, and insertion gain test results are presented for the narrowband. Although the Fucino station is not designed for wideband installation, certain TV test signals and demonstrations were received; only under particularly favorable conditions was reception above the threshold. A phase lock demodulator was found to give better pictures than a standard video demodulator. Effects of a sync restorer and some photos are shown. M.W.R.

N66-10259* Kokusai Denshin Denwa Co., Ltd., Tokyo (Japan).
RESULTS OF TESTS PERFORMED WITH RELAY I AT THE KDD SPACE COMMUNICATIONS STATION
In NASA. Goddard Space Flight Center Relay I Program 1965 p 663-670 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50

Results are summarized for wideband receiving experiments performed with the Relay I satellite at the Kokusai Denshin Denwa space communications station. Although recordings were taken over a relatively short period of time, several conclusions are drawn from the resultant data. Transmission characteristics of satellite-borne Relay instruments and the ground-based receiver were found to be fairly good. Received power was found to fluctuate within a range of −91 to −94 dbm; random noise values varied in range from 43 to 46 db and satisfied the reference value of 43 db. Quality of TV video was, in general, fairly good, although audio signals were not very good. M.W.R.

N66-10261* General Post Office, London (England).
RESULTS OF TESTS PERFORMED WITH RELAY I AT THE GOONHILLY DOWNS SPACE COMMUNICATIONS STATION
W. J. Bray, F. J. D. Taylor, and R. W. White *In* NASA. Goddard Space Flight Center Relay I Program 1965 p 753-767 (See N66-10226 01-31) GPO: HC $4.25; CFSTI: MF $3.50

Results of tests performed with Relay I at the Goonhilly Downs ground station confirm expectations that active communications satellites can provide high-quality stable circuits for television, multi-channel telephony, video frequency telegraphy, and facsimile picture transmission. Very good results were obtained in tests with 600 simulated telephone channels. Propagation tests indicate the possibility of reliable operation with elevation angles of only a few degrees. At no time has interference from either radio-relay systems sharing the same frequency band or other man-made sources been detected on the satellite link. Satellite tracking has been accomplished to within ten minutes of arc from orbital data predicted up to a fortnight in advance and with automatic fine correction to within a minute or two of arc. M.W.R.

N66-10317*# Aeronautical Research Associates of Princeton, Inc., N. J.
COMMUNICATION PROBABILITIES FOR ORDERLY-SPACED SATELLITES
John C. Houbolt Washington, NASA, Nov. 1965 32 p refs (Contract NAS1-4585)
(NASA-CR-327) CFSTI: HC $2.00/MF $0.50 CSCL 12A

Probability equations for determining the percentage of time that communications are possible for various combinations of equal and random spacing of communications satellites are given. The equations are applied to selected communications links including Boston-London, and Los Angeles-Hawaii to bring out the effects of using equal spacing. Improvements are noted, but for randomly-spaced planes and equally spaced satellites per plane, the improvements are only small over the case of completely random distribution. Equally-spaced planes, and equal spacing of the satellites per plane, the most sophisticated ordering, gives the most improvement. L.S.

N66-10535# General Electric Co., Syracuse, N. Y. Radio Guidance Operation.
LUNAR FARSIDE DATA LINK
G. L. Dunn, G. C. Minor, M. E. Myton, C. A. Dashby, and D. R. Rice 14 Apr. 1963 64 p refs
(Rept.-63-SPC-5)

A null-point communications satellite concept is presented for communications between wide spaced terminals on the far side of the moon, and between any point on the far-side lunar surface and an earth based terminal. The dynamic behavior of a satellite in the vicinity of the libration point is investigated analytically by the restricted four-body problem, and the required station keeping thrust is determined. Attitude control requirements are developed and a system implementation for a wide-band communications system is presented. Examinations of optical techniques, the power supply, and the overall vehicle considerations are included. G.G.

N66-10894# Kokusai Denshin Denwa Co., Ltd., Tokyo (Japan). Research Lab.
PROJECT RELAY I REPORT ON COMMUNICATION EXPERIMENTS CONDUCTED AT KDD EARTH STATION, IBARAKI, JAPAN
Apr. 1964 22 p
(RR-1) CFSTI: HC $1.00/MF $0.50

Wideband communication tests and demonstrations performed with the Relay I satellite at the Kokusai Denshin Denwa space communications station in Japan are summarized; positions of the Relay I during the experiments is tabulated. Experimental results are given for insertion and gain stability, noise measurement, nonlinear and linear distortion, received signal power, and television tests. On the basis of short-term testing, it is concluded that the transmission characteristics of the satellite-borne Relay instruments and the ground-based receiver are quite good. Quality of TV video was fairly good, although audiosignals were not good and the effect of spin fading was marked. M.W.R.

N66-10895# Kokusai Denshin Denwa Co., Ltd., Tokyo (Japan). Research Lab.
PROJECT RELAY II REPORT ON WIDEBAND COMMUNICATION EXPERIMENTS CONDUCTED AT KDD EARTH STATION, IBARAKI, JAPAN
Aug. 1964 17 p
(RR-6) CFSTI: HC $1.00/MF $0.50

Results of wideband communication tests and experiments utilizing the Relay II satellite are tabulated. Areas considered include: technical tests with television signals; system noise temperature measurements; a demonstration program; measurement of antenna pattern; and a power reduction experiment. A comparison between calculated and observed orbital data is included. C.T.C.

N66-10896# Kokusai Denshin Denwa Co., Ltd., Tokyo (Japan). Research Lab.
PROJECT RELAY II REPORT ON NARROWBAND COMMUNICATION EXPERIMENTS CONDUCTED AT KDD EARTH STATION, IBARAKI, JAPAN
Oct. 1964 20 p refs
(RR-9) CFSTI: HC $1.00/MF $0.50

Directivities of communication antenna provided with a 6/4 Gc horn were measured by receiving a communication signal on 4170 Mc from the satellite and by setting the axis of antenna gradually off the true direction to the satellite according to orbiting of it only in azimuth or elevation. Examples of directive patterns in planes of azimuth and elevation as observed on Rev. 1038 were shown. It was concluded that: (1) telephone circuit via Relay II had good quality in high signal to noise ratio and low distortion, and was suitable for the international connection; (2) the facility at COMIBA had a margin for 12-channel two way telephoning via Relay II satellite; (3) multiple loop test indicated that a good operation of the echo suppressor was for the telephone circuit via a high altitude satellite; and (4) in order to analyze the interference from the domestic microwave system to the satellite, many tests will be needed. R.W.H.

N66-11235*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ANALYSIS OF US–USSR COMMUNICATIONS EXPERIMENTS CONDUCTED BETWEEN JODRELL BANK OBSERVATORY (UK) AND ZIMENKI OBSERVATORY (USSR) VIA THE ECHO II SATELLITE

Jan. 1965 202 p refs

(NASA-TM-X-55343; X-724-65-466) CFSTI: HC $5.00/MF $1.25 CSCL 17B

Communication experiments were conducted via the Echo II satellite, between the University of Manchester at Jodrell Bank (U.K.) and the Gorki State University at Zimenki (USSR). Two basic types of experiments were conducted: received signal level and communication (or carrier modulation). Significant signal fluctuations were noted throughout the experiments. Possible causes for this characteristic were investigated, and include transmission terminal, transmission media, receiving terminal, and satellite. The experimental methods are described in detail, and numerous graphs and charts are given for the results. Conclusions are presented, with emphasis on the cause for the low signal-to-noise ratio. C.T.C.

N66-12610 Ohio State Univ. Research Foundation, Columbus.

PHOTOGRAMMETRIC MEASUREMENTS OF ECHO II SATELLITE MODELS

Forrest Llewellyn Hicks (M.S. Thesis) 1965 67 p refs

(Contract AF 33(608)-1095)

(AD-620432)

Stereoscopic photographs were taken of several models of the Echo II satellite using the Wild Stereometric camera. Large and small scale work was accomplished on the Wild Autograph A7, including contour maps and coordinate readout. Data were processed to achieve final results which included cross sections, radii of curvature, deviations from best-fitting spheres, and distances above a one-meter chord. Author (TAB)

N66-12975*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

EXPERIMENTAL/THEORETICAL EVALUATION OF A PASSIVE COMMUNICATIONS SATELLITE (ECHO II)

A. Kampinsky and R. K. Ritt (Conductron Corp., Ann Arbor, Mich.) Aug. 1965 52 p refs Presented at U.R.S.I. 1965 Symp. on Electromagnetic Wave Theory, Delft, Netherlands (NASA-TM-X-56996) CFSTI: HC $3.00/MF $0.50 CSCL 17B

Methods developed to predict the radar reflectivity of the Echo II passive communications satellite are described, and their subsequent use in analyzing the data obtained during orbital flight is discussed. A technique was evolved for evaluating the backscatter characteristics of a small segment of the structure, in terms of inherent physical distortions based on the physical construction and the resultant scintillation and communications distortions. Based on these data, theoretical models were constructed. Prior to flight, full size inflated Echo II spheres were evaluated to show the relationships between the skin–stress–scintillation level backscatter qualities. After orbital injection, 20 radar systems provided frequency coverage from VHF to X band, and real time as well as digitized tape radar records of the backscatter qualities. Statistical analyses of these data are included, and the results depicted. The differential equations of equilibrium thin membrane theory are given, and alternatives for developing predictions of full-scale balloon reflectivity are outlined. M.G.J.

N66-13787 Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

RESULTS OF A RADIO COMMUNICATIONS EXPERIMENT BETWEEN THE JODRELL BANK AND ZIMENKI OBSERVATORIES VIA ECHO 2 AND THE MOON AT 162.4 Mc

G. G. Getmantsev, N. I. Kalashnikov, V. L. Bykov, Ye. A. Benediktov, L. M. Yerukhimov et al *In its* Cosmic Res., Vol. 3, No. 4, 1965 18 Oct. 1965 p 197–214 refs (See N66-13776 04-30) CFSTI: HC $6.00/MF $1.50

A one-way radio communications link at 162.4 Mc between the Jodrell Bank and Zimenki observatories made use of Echo II and the moon. Reflected signal level from the Echo satellite was subjected to considerable fluctuation in time. Slow fluctuations, with characteristic times of one to two minutes, are associated with deviations of the satellite surface as well as tracking errors. Rapid fluctuations, of three to 10 seconds, may be due to the presence of inhomogeneities on the satellite surface. Teletype and voice-recording performance were impaired by rapid and deep fluctuations. Average signal level from Echo II fell three to five decibels short of calculated value. Unforeseen losses up to three decibels may be due to difference in polarizations of transmitted and received signals. M.W.R.

N66-13787 Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

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N66-13900# Compagnie Generale de Telegraphie sans Fil, Paris (France).

PASSIVE SATELLITE SYSTEM FOR EUROPEAN TELEVISION BROADCASTING

C. Plottin 14 Jan. 1965 37 p refs

(Rept.-5.023 A) CFSTI: HC $2.00/MF $0.50

The feasibility of a television transmission system based on the use of a large stabilized reflecting satellite placed in a 24 hour equatorial orbit was considered. Such a satellite would be of the retro-directive type and would permit a wide variation in the incident angle of radiation, thereby allowing access from a number of widely separated geographical points. It is shown that a single passive satellite could thus serve the television transmission needs of the major part of Europe. Basically the system consists of a high-power transmitter centrally located in the area to be served, the satellite reflector itself, and ordinary home receivers possibly modified to a minor extent for direct reception of television broadcasts. It is demonstrated that the values of the parameters (satellite size, transmitter power, antenna characteristics, field strength at the receiver, etc.) necessary for realization of such a project are within reason. Author

N66-14276*# National Aeronautics and Space Administration, Washington, D. C.

SATELLITE COMMUNICATIONS: SIX YEARS OF ACHIEVEMENT, 1958–1964

1 Mar. 1965 106 p refs
(NASA-TM-X-57060) CFSTI: HC $4.00/MF $0.75 CSCL 17B

In summarizing the development of communications satellites, the objectives of the United States are reviewed, and a brief history of information communications is presented. The problems encountered in the early phases are discussed, and the research achievements which led to the successes of the passive and active satellites are recounted. The technology of communications satellites, and the significant technical questions undergoing continuing analysis are examined. The legal, economic, and political problems involved in a global system are pointed out, in context with the potential of these communications systems. A bibliography, relating to each project, is included. M.G.J.

N66-15551# Lockheed-California Co., Burbank. Astrodynamic Research Div.
ORBIT ANALYSIS OF COMMUNICATION SATELLITES Final Report, 8 Oct. 1963–1 Jun. 1964
Robert M. Baker, Ray De Ballis, and K. Forster Griffiss AFB, N. Y., RADC, Sep. 1964 234 p refs
(Contract AF 30(602)-3238)
(LR-17944; RADC-TDR-64-314; AD-449418)

This report contains theoretical analyses on the astrodynamics of a solar sailing satellite. The purpose of this report is to provide technical reviews, evaluations, and recommendations related to the astrodynamics portion of a solar sailing satellite, development of an orbit differential correction procedure, and determination of a control philosophy for orbital correction maneuvers. The analyses are mainly qualitative in content; therefore, the course of action followed has been analytical in nature. Numerical analysis has been introduced as necessary, but has been kept to a minimum to avoid a compendium of tables. The analyses, however, are described so that they may be programmed on a computer with a minimum of rearrangement. The specific results and conclusions reached in this study are contained in the respective section for each analysis. Author (TAB)

N66-15678# Royal Aircraft Establishment, Farnborough (England).
RESONANCE EFFECTS FOR SATELLITES WITH NOMINALLY CONSTANT GROUND TRACK
R. R. Allan Aug. 1965 24 p refs
(RAE-TR-65232) CFSTI: HC $1.00/MF $0.50

Since a constant-ground-track satellite would continually pass over the same regions of the Earth, such orbits are in resonance with the longitude dependent part of the Earth's gravitational field. The situation is similar, but not completely analogous, to the case of synchronous satellites. For β revolutions per day, the ground track will oscillate in longitude with a maximum amplitude of $\pm 180/\beta$ degrees, the periods of oscillation being usually of the order of a few years for $\beta = 2$, 3 and 4. These effects depend strongly on the inclination of the orbit. Author

N66-16053*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SIGNIFICANT ELECTRONIC APPLICATIONS AND EXPERIMENTAL RESULTS FROM PROJECT ECHO
H. L. Eaker et al Nov. 1965 102 p refs Presented at WESCON/65, San Francisco, 24–27 Aug. 1965
(NASA-TM-X-55365; X-733-65-448) CFSTI: HC $4.00/MF $0.75 CSCL 17B

Development, testing, instrumentation, and communication experiments are reported for the Echo II project. Consideration is given to implementation, full scale ground tests of prototype spheres, the television system, the application of a beacon telemetry system for measuring orbital performance, and results of communication experiments. Ground inflation tests were made to evaluate the structural and rf backscatter characteristics of spheres as a function of their internal pressure. The television system is described which was used for obtaining pictures of the spacecraft operation including deployment, inflation, and injection into orbit. Also described is the beacon telemetry system used for tracking the satellite during orbit. The communication experiments include measurement of the signal level, coherent bandwidth tests, facsimile transmission tests, and voice and music transmission tests. C.T.C.

N66-16146*# National Aeronautics and Space Administration, Washington, D. C.
BRIGHTNESS VARIATION OF THE ECHO I SATELLITE [YESHCHE RAZ OB IZMENENII BLESKA SPUTNIKA 'EKHO-I']
M. V. Bratiychuk and G. V. Moskaleva Dec. 1965 16 p refs Transl. into ENGLISH from Byul. St. Optich. Nablyudeniya Iskusstv. Sputnikov Zemli (USSR), no. 36, 1963 p 23–9
(NASA-TT-F-9841) CFSTI: HC $1.00/MF $0.50 CSCL 22A

Photometric curves of the Echo I satellite obtained photographically are given. A short period of the brightness variation as a function of the configuration of the satellite's reflect-covered. These periods of brightness variation are tabulated for several days falling during the years 1960 to 1963. An attempt is made to explain the nature of the brightness variation as a function of the configuration of the satellite's reflecting surface and the position of its axis of rotation relative to the observer. L.S.

N66-16163*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
THE ELECTROMAGNETIC TORQUES ON SPHERICAL EARTH SATELLITES IN A RAREFIED PARTIALLY IONIZED ATMOSPHERE
Frank Hohl Feb. 1966 66 p refs
(NASA-TR-R-231) CFSTI: HC $3.00/MF $0.75 CSCL 22A

A theoretical investigation has been made of the torques acting, as a result of electromagnetic interaction, on spherical conducting earth satellites. The analysis has been applied to the 41-meter-diameter satellite Echo II which is in a near polar circular orbit. The calculations have yielded quantitative values for the accelerating and the decelerating torques. A probable explanation of the nearly constant spin rate of Echo II for a long period of time is that the eddy-current torque and the induction torque were in balance. Other torques are shown to be negligible in comparison with these two. Author

N66-16201*# Stanford Research Inst., Menlo Park, Calif.
TECHNICAL PROBLEMS ASSOCIATED WITH COMMUNICATION SATELLITES Supplemental Report, 1 Oct. 1963–30 Apr. 1964
R. G. Gould and W. R. Vincent 18 Jan. 1966 12 p
(Contract NASr-49(08))
(NASA-CR-69897) CFSTI: HC $1.00/MF $0.50 CSCL 17B

The question whether customers would reject circuits with delays of 600 msec is discussed and it is concluded that circuits with these delays have a high enough probability of being acceptable in commercial service to warrant providing them to the general public. Experience with these circuits over the next few years will aid in a choice of ultimate communication satellite system designs. Also, the question of whether or not it is necessary in an international telephone connection to limit the propagation time between two subscribers is discussed. Recent tests have shown that international connections probably would not cause adverse subscriber reaction due to the combined effect of delay and echo suppressors if the mean

one-way propagation time is increased from near zero to the order of 150 ms. As the propagation time is increased beyond 150 ms, subscriber difficulties increase, and the rate of increase of difficulty rises, up to and including the maximum one-way propagation time tested, namely 400 ms. E.E.B.

N66-16703*# RAND Corp., Santa Monica, Calif.
COMMUNICATION SATELLITE OUTPUT DEVICES
W. F. Feldman Jun. 1965 49 p refs Revised
(Contract NASr-21(02))
(NASA-CR-70037; AD-622418) CFSTI: HC $2.00/MF $0.50 CSCL 09F

Presented are results of a study to investigate the relative ability of semiconductor devices, such as tunnel diodes, transistors, and varactor diodes, and vacuum tube amplifiers such as, triodes, klystrons, amplitrons and TWTs to generate signal power efficiently at frequencies of 1 to 10 kMc and power levels of 0.1 to 100 watts for use as communication satellite output devices. M.R.W.

N66-16937*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
POSTLAUNCH STRUCTURAL ANALYSIS OF ECHO II SATELLITE
Hossein Bahiman Washington, NASA, Feb. 1966 13 p
(NASA-TN-D-3170) CFSTI: HC $1.00/MF $0.50 CSCL 22B

Telemetered data from the Echo II (1964 04A) satellite revealed an unexpectedly high spin rate. An analysis was performed to estimate the effects of the resulting centrifugal forces. Calculations were made for the case of the axis orientation that would give the greatest distortion, namely, spin about the polar axis. It was discovered from these calculations that deviation from spherical shape was greatest at the beacons. The maximum deviation was estimated at about 3 inches with local wrinkling of a fraction of an inch in depth. Wrinkling of other areas of the satellite surface was postulated as a result of a shifting spin axis during the initial orbits. Author

N66-16944# Joint Publications Research Service, Washington, D. C.
TELEGRAMS THROUGH SPACE
V. Belikov 25 Jan. 1966 9 p Transl. into ENGLISH from Izv. (Moscow), 30 Dec. 1965 p 1
(JPRS-33876; TT-66-30319) CFSTI: $1.00

The Soviet communications satellite, Molniya 1, is described. Its potential for serving large areas with telephone, telegraph, and television communications is discussed. R.N.A.

N66-17009# Naval Research Lab., Washington, D. C.
DIRECTIONAL EQUILIBRIUM OF AN ARTIFICAL SATELLITE ENVELOPING A NONUNIFORM REGION OF A GRAVITATIONAL FIELD
P. A. Crafton 25 Oct. 1965 14 p ref
(NRL-6321; AD-624592) CFSTI: HC $1.00/MF $0.50

Certain artificial satellites used for communications and/or navigation require means of directional stabilization. If the satellite encompasses an essentially uniform region of the gravitational field, it is in neutral directional equilibrium in that force field. The creation of an artificial satellite with a discrete distribution of mass permits us to have a satellite encompassing a nonuniform region of the gravitational field although having a relatively low total mass. The basic mathematical relationships are developed that must be satisfied by any gravity-gradient satellite in order that it have stable directional equilibrium. The satellite is assumed to have a discrete distribution of mass, and is assumed to be not subjected to other body forces, radiation forces, and disturbing forces.
Author (TAB)

N66-18027# Joint Publications Research Service, Washington, D. C.
RAINBOW WHICH BECAME RELATED TO "MOLNIYA" COLOR TRANSMISSION OVER 80,000 KILOMETERS
A. Grif 25 Jan. 1966 9 p Transl. into ENGLISH from Radio (Moscow), no. 8, Aug. 1965 p 32-33
(JPRS-33879; TT-66-30322) CFSTI: $1.00

A narrative description of an experiment comparing the transmission of a color television program through Molniya-1 (Lightning-1), an earth satellite, against transmission over a line, is presented. The image on the screen of the sets travelled more than 80,000 kilometers, and despite the enormous propagation velocity of radio waves, required about 0.3 second to make the trip. The quality of transmission through the communications satellite was considered to be good. L.S.

N66-18367*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
FABRICATION AND PRESSURIZATIONS TECHNOLOGY FOR IMPROVEMENT OF SURFACE ACCURACY OF PASSIVE COMMUNICATIONS SATELLITES
David C. Grana and Walter E. Bressette [1965] 22 p Presented at the 2d Aerospace Expandable Struct. Conf., Minneapolis, 25-27 May 1965
(NASA-TM-X-56394) CFSTI: HC $1.00/MF $0.50 CSCL 13H

This paper summarizes the results of tests on a series of inflatable gore-type spheres to determine the effects of the number of gores and the manufacturing process on the surface conditions and radius of curvature accuracy before, during, and after internal pressurization. Nine 12-foot-diameter spheres were manufactured from Echo II type skin material using three fabrication techniques. The first technique used the present Echo I and Echo II construction. Spheres having 32, 48, and 64 gores were manufactured in this manner. The second technique employed a mandrel device to fabricate a 48-gore sphere, and the thrid consisted of the fabrication of a 48-gore sphere on a hemispherical mold. Data of sphere surface conditions and radius of curvature before, during, and after internal pressurization were measured at various locations on the spheres to an accuracy of 0.012 inch by the method of photogrammetry. The data are presented in the form of contour plots and cross sections of these contour plots from which manufacturing imperfections, shape, local radii of curvature, material elongation, and surface irregularities can be determined and compared to theoretical predictions. Author

N66-18372*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SYSTEM REQUIREMENTS FOR A DIRECT R.F. TO R.F. RE-ENTRANT TRAVELING WAVE TUBE COMMUNICATIONS SATELLITE TRANSPONDER
Louis J. Ippolito [1965] 30 p refs Presented to the Satellite Commun. Session, Intern. Space Electron. Symp., Miami Beach, Fla., 2-4 Nov. 1965 Submitted for Publication
(NASA-TM-X-56546) CFSTI: HC $2.00/MF $0.50 CSCL 17B

Conventional techniques for obtaining frequency conversion and amplification in an active repeater communications satellite down-convert the received radio frequency signal to an intermediate frequency for amplification and then up-convert to a new radio frequency for further amplification and re-transmission. This paper describes the requirements for a re-entrant traveling wave tube frequency converter system which accomplishes all amplification and frequency translation at microwave frequencies, eliminating the bandwidth and signal handling limitations of conventional systems employing an

intermediate frequency. Transponder requirements for a wide-band synchronous orbit communications satellite link are presented and the effects of multiple carriers on the system response are investigated. System and component design criteria are developed for the link and experimental re-entrant systems are described. Author

N66-18385*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

STRUCTURAL CONSIDERATIONS FOR AN EXPANDABLE LENTICULAR SATELLITE

Jerry L. Humble [1965] 24 p Presented at the 2d Aerospace Expandable Struct. Conf., Minneapolis, 25–27 May 1965 (NASA-TM-X-56352) CFSTI: HC $1.00/MF $0.50 CSCL 22B

The lenticular satellite consists of several types of expandable and inflatable structural components combined into one configurational system which can be packaged into a very small volume and erected in orbit. The types of expandable structures being utilized include: (1) inflatable membranes, (2) rigidized membranes, (3) unfurling members, and (4) extendable members. The paper opens with an exploration of the lenticular satellite basic philosophy, depicting the weight advantage of the lenticular shape over a sphere with similar communications capabilities. The paper then proceeds with a discussion of the various structural components. Starting with the basic lenticular shape, a functional configurational system is logically developed with the addition of the major structural components and an explanation of their functions. The lens, as a microwave reflector, is of primary interest and all other components are intended to implement its usefulness. It is an inflatable strain rigidized membrane. The torus is used only to maintain the lenticular shape during the pressurization-rigidization cycle. Author

N66-18458*# National Aeronautics and Space Administration, Washington, D. C.

SIGNIFICANT ACHIEVEMENTS IN SPACE COMMUNICATIONS AND NAVIGATION, 1958–1964

1966 73 p refs

(NASA-SP-93) GPO: HC $0.45; CFSTI: MF $0.75 CSCL 17B

The early history of satellite communications development is reviewed, and the highlights of communications achievements are noted. Details are given on the launchings and operational capabilities of the passive and active communications satellites, and their performance in transcontinental and intercontinental experiments is assessed. Technological progress is summarized, and the formation of the Communications Satellite Corporation for exploitation of the commercial possibilities in a global system is discussed. A bibliography is included. M.G.J.

1965
IAA ENTRIES

A65-14320
A HIGH ACCURACY PERTURBATION METHOD WITH DIRECT APPLICATION TO COMMUNICATION SATELLITE ORBIT PREDICTION.
A. J. Claus and A. G. Lubowe (Bell Telephone Laboratories, Inc., Analytical and Aerospace Mechanics Dept., Whippany, N.J.).
IN: INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, 5TH, TOKYO, JAPAN, SEPTEMBER 2-7, 1963, PROCEEDINGS. [A65-14290 05-31]
Edited by Tsuyoshi Hayashi.
Tokyo, AGNE Corp., 1964, p. 371-375.

Description of a second-order perturbation method for a satellite similar to the Telstar communication satellite. This method considers the second-order perturbations due to the second harmonic (J_2^2) of the Earth's potential, the first-order perturbations due to the third and fourth harmonics (J_3, J_4), and the first-order perturbations due to the gravitational attraction of the Sun and the Moon (K_S, K_M). The method has been programmed and tested extensively. Some comparisons of the J_2 and J_2^2 expressions vs double-precision numerical integration of Newton's law (with the inverse-square gravity and the second harmonic as forces) are given. It is noted that the accuracy is as expected and that computing time is reduced by a factor of over 400. The numerical integration scheme is being revised to include J_3, J_4, K_S, K_M, so that this portion of the second-order method can be more completely tested. M.M.

A65-14348
AN EXPERIMENT ON DEGRADATION OF CONVERSATION WITH ECHO-FREE LONG PROPAGATION TIME.
Akira Miura, Kuniichi Nagata, and Hiroshi Tsuru (Nippon Electric Co., Ltd., Communication Research Laboratory, Kawasaki, Japan).
IN: INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, 5TH, TOKYO, JAPAN, SEPTEMBER 2-7, 1963, PROCEEDINGS. [A65-14290 05-31]
Edited by Tsuyoshi Hayashi.
Tokyo, AGNE Corp., 1964, p. 759-769. 10 refs.
Research supported by the Japan Science and Technology Agency.

Experimental investigation of the degradation of telephone conversations in connection with long propagation time. Examples of the satellite situations and the propagation time considered are shown. The tests were planned on circuits having one-way propagation time within 600 msec. The following conclusions are reached: (1) a relationship has been found between propagation time and the prolongation ratio of conversation. It is stated that the prolongation of conversation is about 13% on a two-synchronous-satellite tandem system; (2) the SNR did not seriously affect the duration of the telephone conversation; and (3) confusion of conversation was experienced twice on a circuit having 1.8-sec and 3.6-sec one-way propagation time, but the confusion vanished quickly and normal conversation was restored. It is stated that this phenomenon may be explained by human adaptivity and the simplicity of the conversation on the diagrammatic puzzles, and that therefore it seems that confusion in conversation may not cause serious degradation on a satellite communication system. M.M.

A65-14354
THE OPTIMUM FREQUENCIES FOR AN ACTIVE SATELLITE SYSTEM.
W. T. Blackband (Ministry of Aviation, Royal Aircraft Establishment, Farnborough, Hants., England).
IN: INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, 5TH, TOKYO, JAPAN, SEPTEMBER 2-7, 1963, PROCEEDINGS. [A65-14290 05-31]
Edited by Tsuyoshi Hayashi.
Tokyo, AGNE Corp., 1964, p. 823-830.

Discussion of the factors influencing the choice of optimum working frequencies for an active communication satellite system. Optimum frequencies for up and down links are considered separately. It is stated that the assumption of fixed size of fixed gain for the satellite aerial leads to different values for the optimum frequency. It is concluded that, for the present generation of active satellites, the power radiated from the satellite will be small, and consequently, the critical link is likely to be that from satellite to ground. As the satellite aerials are likely to be fixed in gain by the requirements of service area, the optimum frequency for the down link will be in the 3- to 4-gc band in the absence of rain. This optimum frequency would not be altered very much even by heavy rain. In most cases the satellite equipment will permit the operation of up and down links on different frequencies, and the frequency of the up link would be chosen to suit conditions. It is pointed out that, because there is no marked dependence of performance on frequency, it is likely that the frequency chosen would be between 5 and 8 gcs, namely, above that needed for the down links and yet below the atmospheric absorption band. M.M.

A65-14355
RELAY I SPACECRAFT PERFORMANCE.
Robert H. Pickard (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, 5TH, TOKYO, JAPAN, SEPTEMBER 2-7, 1963, PROCEEDINGS. [A65-14290 05-31]
Edited by Tsuyoshi Hayashi.
Tokyo, AGNE Corp., 1964, p. 831-842.

Description of the performance of Relay I, an experimental communications spacecraft. The factors leading to the design of an experimental communications satellite are considered. It is stated that limitations in the bandwidth of available klystrons for ground transmitters required the use of modulation index tripling in the spacecraft to obtain usable SNR on the spacecraft-to-ground path. Simultaneous two-way telephony experiments required that two separate IF channels be provided to prevent signal suppression and to reduce cross-modulation products. It was necessary to provide 20 command channels and 128 multiplexed PGM telemetry channels to operate the spacecraft and evaluate its performance. Pre-launch performance evaluation of the communications equipment consisted of measuring parameters such as SNR, group delay, noise loading, bandwidth, crosstalk, frequency, and power output. A summary of experimental results obtained from in-orbit operations indicates close correlation to prelaunch measurements. Illustrations of experimental results are given. (Author) M.M.

A65-14370
A SMALL EXPERIMENTAL COMMUNICATIONS SATELLITE GROUND TERMINAL.
T. W. G. Dawson, R. E. Hall, H. Herbert, W. A. Jackson, D. E. T. Nichols, and C. H. Weaving (Ministry of Aviation, Royal Aircraft Establishment, Farnborough, Hants., England).
IN: INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, 5TH, TOKYO, JAPAN, SEPTEMBER 2-7, 1963, PROCEEDINGS. [A65-14290 05-31]
Edited by Tsuyoshi Hayashi.
Tokyo, AGNE Corp., 1964, p. 985-994.

General description of a small communications satellite ground terminal which was constructed so that engineers, previously inexperienced in the field, could, at low financial cost, become acquainted with the problems involved in achieving passive satellite communications. The 17-ft-diam. parabolic aerial has an altazimuth mount, the electric motors being controlled from paper tape which is prepared beforehand using an electronic computer fed with the basic orbital elements. Transmissions are at 9.34 gc and are also planned for approximately 8.4 gc; such high frequencies are of interest because, within current engineering limitations, they enable maximum SNR to be achieved in passive satellite communication links. The equipment includes a 1-kw cw transmitter, an 8-kw transmitter still under construction, an experimental cavity maser, narrowband receivers incorporating equipment for the elimination of rapidly changing Doppler shift, and frequency-multiplier chains for the generation of stable microwave frequencies. Electronic switches allow rapid time-sharing between the transmitter and receiver for monostatic experiments. (Author) M.M.

A65-14961
SERVO PROXIMITY DEVICE USED FOR SENSING ECHO II POSITION.
J. E. Holthaus and T. E. Spink (Westinghouse Electric Corp., Aerospace Div., Baltimore, Md.).
IN: ANNUAL EAST COAST CONFERENCE ON AEROSPACE AND NAVIGATIONAL ELECTRONICS, 11TH, BALTIMORE, MD., OCTOBER 21-23, 1964. TECHNICAL PAPERS. [A65-14925 05-21]
Conference sponsored by the Institute of Electrical and Electronics Engineers, Baltimore Section, and Aerospace and Navigational Electronics Group.
North Hollywood, Western Periodicals Co., 1964, p. 3.4.2-1 to 3.4.2-6.

Description of a unique device designed to detect surface movement or deformation of the Echo II Balloon during ground testing conditions. The device utilizes a proximity switch for sensing the presence of a metallic material. The switch in turn is positioned by a relay servosystem driven by the signal of the sensor. The device is shown to be capable of detecting movements with an accuracy of 0.005 in. at rates up to 3 in./sec without contacting the balloon surface. Static ground tests are conducted under the direction of NASA to acquire data on reflectivity, sphericity, and skin tension of the 135-foot Echo II Balloon prior to launch into orbit. (Author) J. R.

A65-14970
RELAY - RELIABILITY IMPROVEMENT THE GOAL.
L. Gomberg and A. Sternberg (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N. J.).
IN: ANNUAL EAST COAST CONFERENCE ON AEROSPACE AND NAVIGATIONAL ELECTRONICS, 11TH, BALTIMORE, MD., OCTOBER 21-23, 1964. TECHNICAL PAPERS. [A65-14925 05-21]
Conference sponsored by the Institute of Electrical and Electronics Engineers, Baltimore Section, and Aerospace and Navigational Electronics Group.
North Hollywood, Western Periodicals Co., 1964, p. 3.6.1-1 to 3.6.1-3.

Presentation of a case history of an actual experience, including problems, with a communications satellite, Relay I (1962 Beta Upsilon 1). This includes a description of the actual system and the corrective actions made on Relay II (1964 3A) as a result of these problems. In particular, spacecraft subsystems, reliability requirements, testing programs, and mission profile and environmental tests are considered. J. R.

A65-15345 #
PHOTOELECTRIC MEASUREMENTS OF THE ECLIPSES OF ECHO 2 [PHOTOMETRIE PHOTOELECTRIQUE DES ECLIPSES DE L'ECHO II].
F. Link, L. Neužil, and I. Zacharov (Académie des Sciences, Institut Astronomique, Ondřejov, Czechoslovakia).
Astronomical Institutes of Czechoslovakia, Bulletin, vol. 15, no. 6, 1964, p. 256-258. In French.

Application of a photometer-photomultiplier-loop oscilloscope arrangement to a study of eclipses of the satellite Echo 2. Such eclipses present advantages in investigations of the upper atmosphere in that they are more frequent and permit higher resolution than is the case with lunar eclipses. Data reduction required a knowledge of the relative position of the satellite with respect to the Earth's shadow. This was provided by tables of the Smithsonian Astrophysical Observatory, which were found to be accurate enough for determining the plane of the orbit in space, but not so satisfactory for fixing the actual position of the satellite in orbit. Supplementary visual observations helped to correct errors of this kind. Measurements of the brightness variation as the satellite approached the penumbral region gave evidence of strong light absorption in the atmosphere above 100 km, in keeping with the findings of Frith, who reported the results of direct measurements of the solar illumination along the orbit of Ariel 2. W. M. R.

A65-15347 #
DETERMINATION OF THE COMMUNICATION TIME FOR SYSTEMS USING ARTIFICIAL EARTH SATELLITES (ISZ) [OPREDELENIE PRODOLZHITEL'NOSTI SVIAZI V SISTEMAKH S ISPOL'ZOVANIEM ISKUSSTVENNYKH SPUTNIKOV ZEMLI (ISZ)].
R. M. Stetsevich.
Elektrosviaz', vol. 18, Dec. 1964, p. 1-8. 7 refs. In Russian.

Derivation of expressions for periods of time during which an Earth satellite is visible simultaneously from two points on Earth - i. e., time during which the satellite's geocentric projection is situated within a single area formed by two individual visibility zones on Earth. The relationships established are illustrated graphically and numerically. An approximate estimate of the maximum duration of a communication period is furnished. V. Z.

A65-15861
SPACE BEACONS IN NAVIGATION [KOSMICHESKIE MAIAKI V NAVIGATSII].
L. I. Gordeev, V. P. Zakolodiazhnyi, E. F. Suvorov, V. A. Fufaev, and E. P. Churov.
Moscow, Voenizdat, 1964. 203 p. In Russian.

The book introduces the reader to the principles of utilizing Earth satellites for guidance and navigation. It evaluates the efficiency of a satellite-based navigation system in determining the position of a ship at sea and reviews the laws of satellite motion and methods of predicting the position of satellites in space. Methods of measuring navigation parameters are examined and the effects of the atmosphere and ionosphere on the precision of these measurements assessed. The circuits and elements of a satellite-based navigation system are discussed and the Transit navigation system is examined in some detail. The book is based on US material and designed for readers interested in maritime navigation. V. P.

A65-16412
EARTH TO SATELLITE TWT AMPLIFIER.
R. J. Collier.
Bell Laboratories Record, vol. 42, Nov. 1964, p. 356-362.

Description of the M4040 traveling wave tube used with the ground-station amplifiers of the Telstar project. M4040 TWT's, the result of an intensive 20-month development program, have been in operation in Andover, Me., since Jan. 1962 and in Pleumeur-Bodou, France, since June 1962. The TWT is a 230-lb device which, although it is highly fragile, has a rated output power of 2000 watts in the frequency range 6350 to 6450 Mc. Its small signal gain is 31 db and its gain at the 2000-watt level is 28 db. It employs a magnetic field of 730 Oe and an operating voltage of 17 kv. Components described in detail are: the electron gun, the focusing scheme, the slow wave structure, the waveguides, and the collector. D. H.

A65-16420
THE NEW COMSATS.
Bernard Kovit.
Space/Aeronautics, vol. 42, Oct. 1964, p. 32-41.

Review of operational experience acquired in the field of communications satellites and of the outlook for future development in this field. The argument over whether the military should have its own comsat system or share ComSatCorp's system is discussed. The author apparently feels that the military should have its own system, since the profit motivation underlying the development of a commercial system is irrelevant in the case of a military system. The progress represented by quasi-experimental comsats like Syncom 3 is attributed to increases in booster payload capacity. The internal differences between Syncom 2 and Syncom 3 are described. With the Early Bird satellite ComSatCorp will open the world's first commercial comsat hook-up by mid-'65. It will provide experience in operating a commercial comsat before the full-scale system is established by mid-'67. Three designs for a large-scale commercial comsat network are being considered. Hughes' synchronous comsat appears to have a definite edge over the other two study designs. A very large growth in the demand for transoceanic communications services is forecast for the next two decades. This greatly increased demand for channels will call for high-power satellites with solid-state repeaters, passive stabilization, and nuclear energy sources. A. B. K.

A65-17495
MULTIPLE ACCESS TO A HARD-LIMITING COMMUNICATION-SATELLITE REPEATER.
Joseph M. Aein (Institute for Defense Analyses, Research and Engineering Support Div., Arlington, Va.).
IEEE Transactions on Space Electronics and Telemetry, vol. SET-10, Dec. 1964, p. 159-167. 6 refs.

Analysis of the communication capability of a hard-limiting satellite repeater when spread-spectrum signals are used for asynchronous access multiplexing. It derives formal results which are said to indicate the most suitable system bandwidth and the resulting maximum number of simultaneous users as a function of the ratio of the received signal power (over the entire system bandwidth) from the satellite to the available noise power density at the ground station receiver. The assumptions and approximations necessary to achieve the formal results are set forth, and their weaknesses are examined. (Author) M.M.

A65-18102 #
HIGH ACCURACY ORBIT PREDICTION FROM NODE TO NODE.
Anthony G. Lubowe (Bell Telephone Laboratories, Inc., Analytical and Aerospace Mechanics Dept., Whippany, N. J.).
Astronautica Acta, vol. 10, no. 3-4, 1964, p. 252-261. 6 refs.

Conversion of the high accuracy orbit prediction method, developed earlier by the author et al. as part of the tracking and prediction program for the Telstar satellite, to the special case of node-to-node operation. Node-to-node prediction is shown to be suitable for the following uses: (1) tracking and prediction for a worldwide satellite communication system utilizing field computers with low storage capacities and low computation speed; and (2) long-range orbit prediction using multistep methods. Total storage requirements are reduced by 37% and computation time on the IBM 7094 by 12%. J.R.

A65-18272 #
THE ORBITAL PERIOD OF ECHO 1.
D. M. Brierley.
British Astronomical Association, Journal, vol. 75, Dec. 1964, p. 29-31.

Accurate determinations of the orbital period of Echo I (1960 Iota 1) over a 1144-day period with minimal equipment. It has beer found convenient to record a number of positions - say 6 - on a transit, interpolate for the azimuth and time of maximum elevation, and derive the apex longitude and time by assuming that maximum elevation corresponds to closest approach. The period is then derived from two apex times. The observed nodal period is compared graphically with the anomalistic period computed by the Smithsonian Astrophysical Observatory. Cyclical decreases in the period are attributed to changing radiation pressure as the plane and perigee of the orbit change with respect to the Earth-Sun line. Increases in solar activity result in a decrease of orbital period because the density of the upper atmosphere increases at these times. It is considered certain that Echo I will perish as this density increases at the time of the next sunspot maximum around 1968. D.H.

A65-18743
SYNCOM RELIABILITY.
E. J. Althaus and J. C. Meyer (Hughes Aircraft Co., Space Systems Div., Culver City, Calif.).
IN: NATIONAL SYMPOSIUM ON RELIABILITY AND QUALITY CONTROL, 11TH, MIAMI BEACH, FLA., JANUARY 12-14, 1965, PROCEEDINGS. [A65-18710 09-15]
Symposium sponsored by the Institute of Electrical and Electronics Engineers, American Society for Quality Control, American Society of Mechanical Engineers, Institute of Environmental Sciences, and Society for Nondestructive Testing.
New York, Institute of Electrical and Electronics Engineers, 1965, p. 303-312.

Review of the reliability of spin-stabilized spacecraft, or Syncom, program. The orbital maneuvers, reliability, parts and test programs, and design review are discussed, and data for control maneuvers and propellant utilization reliability apportionment, and the types and quantities of electronic parts used are tabulated. Changes made in later models, from Syncom 1 through 3, are summarized. It is concluded that Syncom 2 has demonstrated the feasibility of using synchronous orbit satellites as a practical and economical means of attaining worldwide communications. The success of the Syncom is attributed to: (1) the basic simplicity of design of the satellite, (2) a rigorous test program that revealed problem areas early enough to make effective changes, (3) a parts program that provided screening that results in only high quality parts for the spacecraft plus the fact that only "proven" parts were used in the design, (4) effective use of design reviews, and (5) a closed-loop trouble-failure reporting system. M. L.

A65-18801
THE LINK FROM A COMMUNICATION SATELLITE TO A SMALL GROUND TERMINAL.
Nathaniel E. Feldman (RAND Corp., Santa Monica, Calif.).
Microwave Journal, Oct. 1964. 6 p. 10 refs.
Contract No. NASr 21(02).

Analysis of factors influencing information rate in a satellite-to-ground communications link. The ground station is assumed to employ a relatively simple, small receiving system; 10-ft-diam. antennas and 150°K uncooled parametric amplifiers (resulting in a voice-channel bandwidth of 4 kc) are assumed. When definite values are assumed for satellite radiated microwave power, antenna gain, maximum slant range for 0-db gain, system losses, noise temperature, frequency modulation index, feedback factor, ratio of channel capacity to noise, and signal-to-noise ratio, it is possible to evaluate the effects of antenna pattern, satellite altitude, and satellite stabilization on information rate. The useful technique of purchasing tracking-antenna aperture in small units is discussed; it is believed that a significant cost benefit may be gained by using a large number of small antennas to create the equivalent of one big antenna. D.H.

A65-19034
SOME ORBITS FOR COMMUNICATION-SATELLITE SYSTEMS AFFORDING MULTIPLE ACCESS.
D. I. Dalgleish and A. K. Jefferis (General Post Office, Engineering Dept., London, England).
Institution of Electrical Engineers, Proceedings, vol. 112, Jan. 1965, p. 21-30.

Consideration of the influence of orbital parameters on the economic provision of simultaneous multiple interconnections between large numbers of Earth stations in a global communication-satellite system. It is stated that, in order to provide direct communication between many countries which may be widely separated geographically, and also to avoid certain technical problems, it is most important to provide the interconnections wherever practicable on a one-hop basis. It is also desirable that each Earth station shall work simultaneously to as few satellites as possible. It is noted that these requirements can most readily be met by a system of geostationary satellites. However, such a system may prove unacceptable from other points of view - e.g., that of transmission delay. From an examination of the relations between coverage zones, orbital parameters, and number of satellites required, it is concluded that large coverage zones may also be obtained with relatively few satellites by using systems in which each satellite follows the same Earth track as its predecessor. The coverage provided by a number of such systems is discussed. (Author) M.M.

A65-19143 #
EARLY BIRD.
Richard M. Bentley (Hughes Aircraft Co., Aerospace Group, Space Systems Div., El Segundo, Calif.).
Astronautics and Aeronautics, vol. 3, Mar. 1965, p. 26-29.

Description of the HS-303 Early Bird synchronous communication satellite which is expected to begin commercial operations about May 1965. Like its predecessor Syncom 3, Early Bird will be orbited by a thrust augmented delta rocket fired from Cape Kennedy. Its communications system employs two 25 Mc IF receivers; it has 240 duplex voice channels with two-carrier operation; it has redundant 6-watt TWT transmitters; the antenna gain is 9 db in transmitting and 4 db in receiving. Discussion includes: program objectives, Early Bird development, launch plans, and experimental operation. D.H.

A65-19330
THE CURRENT NASA COMMUNICATIONS SATELLITE PROGRAM.
Leonard Jaffe (NASA, Office of Space Science and Applications, Communication and Navigation Programs Div., Washington, D. C.).
IN: INTERNATIONAL ASTRONAUTICAL CONGRESS, 13TH, VARNA, BULGARIA, SEPTEMBER 1962, PROCEEDINGS. VOLUME 2. [A65-19311 09-30]
Edited by Nicolas Boneff and Irwin Hersey.
Vienna, Springer-Verlag, 1964, p. 830-855.

Description of projected experiments with low- or intermediate-altitude passive reflectors, low- or intermediate-altitude active repeaters, and high-altitude, synchronous, active repeaters toward the establishment of an operational satellite communications system. The Telstar, Relay, Syncom, and Echo programs are described. Estimates of the number of satellites required for substantially continuous service between terminal points are made on the assumption that, without fairly complex provisions for controlling the position of an individual satellite in orbit, it must be expected that the satellites will come, after a period of time, to an essentially random set of spacings. Efforts to reduce the weight of passive satellites have led to a study of three alternatives to the reflecting-sphere configuration: the sphere with etched holes in the metallic foil that constitutes the reflecting surface, the sphere of an appropriately sized wire mesh, and the gravity-stabilized spherical segment. International cooperation is represented by programs of Rio de Janeiro, Goonhilly Down, and Pleumeur-Boudou ground-station facilities, of which photographs are given. In 1945, 12 years before Sputnik I, Clarke, the British science writer, first proposed the use of satellites for communications, envisioning the use of manned space stations for this purpose. However, it is considered infeasible to rely on man to repair failures in space, and the current NASA effort is directed toward the construction of unattended communications satellites that will function reliably and dependably in space for many years. W. M. R.

A65-19331
RELAY, AN EXPERIMENTAL SATELLITE FOR TV AND MULTICHANNEL TELEPHONY COMMUNICATIONS.
R. Pickard, S. Roth, and J. D. Kiesling (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N. J.).
IN: INTERNATIONAL ASTRONAUTICAL CONGRESS, 13TH, VARNA, BULGARIA, SEPTEMBER 1962, PROCEEDINGS. VOLUME 2. [A65-19311 09-30]
Edited by Nicolas Boneff and Irwin Hersey.
Vienna, Springer-Verlag, 1964, p. 856-879.

Description of Project Relay, the basic objective of which is to study the problems of long-haul communications systems using active, low-altitude, nonsynchronous satellites. Supported by various private companies and government agencies in a number of countries, the project includes three flights to be launched from the Atlantic Missile Range using the Delta launch vehicle. The various electronic systems of the satellite link are described as they relate to (1) wide-band communications; (2) command, telemetry, and tracking; and (3) special radiation experiments. The communications experiments to be performed involve trans-Atlantic television, one-way and two-way multichannel telephony, and high-bit-rate digital transmission. The transmission medium characteristics to be examined will include attenuation, phase changes, interference, and time delay. The satellite receiver signal strength, telemetry data, and attitude will be correlated with ground-station performance (antenna elevation, pointing error, weather conditions, and Doppler shifts). Television signals will be examined for resolution, synch compression, streaking, smearing, ringing, interference, and the effects of pre-emphasis. The spacecraft also carries experiments to determine the extent of radiation damage to various types of solar cells and silicon diodes. W. M. R.

A65-19332
WORLD COMMUNICATION SATELLITE SYSTEM.
G. K. C. Pardoe (British Space Development Co., Ltd., London, England).
IN: INTERNATIONAL ASTRONAUTICAL CONGRESS, 13TH, VARNA, BULGARIA, SEPTEMBER 1962, PROCEEDINGS. VOLUME 2. [A65-19311 09-30]
Edited by Nicolas Boneff and Irwin Hersey.
Vienna, Springer-Verlag, 1964, p. 880-915.

Results of a study of a communications satellite system to provide world coverage, but particularly suited to the global interests of the British Commonwealth and certain European countries. The study assumes that some form of global satellite system was already in operation before the European system, and the traffic studies have been carried out on this basis, thus influencing the catchment areas of the traffic. Over a 20-yr period, an average annual growth rate of 9.6% (overall growth factor of 6.35) of telephone traffic is estimated. Different forms of traffic loading are considered and it is shown that the main revenue would come from the telephone and telegraph services. The system design is discussed first with reference to the relative merits of low, medium, and synchronous altitude orbits. If the apparently fundamental problem of time delay is substantiated, it is proposed that the first form of commercial operation would best make use of nine equally spaced station-keeping satellites located in the same circular orbit moving east in relation to the Earth at an altitude of 7480 nautical miles. Development costs of the rocket vehicle are not discussed, but the satellite system development, deployment, and operational costs over a 20-yr period are given, together with revenue figures, which are expected to total some 700 million pounds sterling gross. W. M. R.

A65-19334
CHARACTERISTICS OF PASSIVE COMMUNICATION SATELLITES WITH LAMBERTIAN SURFACES.
Herbert P. Raabe (Litton Industries, Inc., Applied Science Div., Minneapolis, Minn.).
IN: INTERNATIONAL ASTRONAUTICAL CONGRESS, 13TH, VARNA, BULGARIA, SEPTEMBER 1962, PROCEEDINGS. VOLUME 2. [A65-19311 09-30]
Edited by Nicolas Boneff and Irwin Hersey.
Vienna, Springer-Verlag, 1964, p. 939-953.

Scattering characteristics and statistical properties of surfaces that reflect diffusely according to Lambert's law. Such surfaces are found attractive for passive communications satellites because they afford a directional pattern that is well matched to the optimum pattern for low-orbit satellites, can be readily realized, and permit very large weight reductions; there is a wide margin for improvement in weight reduction, since the weight of Echo I, for example, is 1000 times heavier than the theoretical minimum. The signal is preferably stabilized by combination frequency diversity. It is found that with a Lambertian surface, a spherical shape is no longer necessary, and higher reliability is gained from a polyhedral structure. Compared with a rigidized specularly reflecting sphere, a Lambertian reflector provides a 7-db stronger echo for the same weight. A model that has been tested is described; it consists of a regular dodecahedron covered with wrinkled, perforated foil of an aluminum-polyester laminate. W. M. R.

A65-19335
ON THE MOTION OF ECHO I-TYPE EARTH SATELLITES.
L. N. Rowell, M. C. Smith, and W. L. Sibley (RAND Corp., Santa Monica, Calif.).
IN: INTERNATIONAL ASTRONAUTICAL CONGRESS, 13TH, VARNA, BULGARIA, SEPTEMBER 1962, PROCEEDINGS. VOLUME 2. [A65-19311 09-30]
Edited by Nicolas Boneff and Irwin Hersey.
Vienna, Springer-Verlag, 1964, p. 954-966.
Contract No. NASr-21(02).

Attempt to explain anomalous changes that occurred in the orbit of the satellite 1960 Iota 1 (Echo I) during the first four months after launch in Aug. 1960. The experimentally determined orbit is compared with theoretical values of the orbital parameters taken from the Smithsonian Tables and integrated on an IBM 7090. The perturbations caused by Earth bulge and the gravitational attractions of the Sun and Moon are treated as known quantities, while altitude (atmospheric drag) and solar activity (radiation pressure, direct and reflected) effects are inferred for altitudes between 950 and 1500 km from the observed motion of the satellite. It appears that for certain orientations of the satellite, the effects of radiation pressure and air drag on perigee and the semimajor axis of the elliptical orbit may act in the same direction. Numerical calculations show that these effects may be used to greatly increase or

even indefinitely extend the lifetimes of balloon-type satellites. Predictions are made of the future behavior of Echo I; one suggests its destruction on its sixth dip below 900 km in the spring of 1965. W.M.R.

A65-19336
COMPARISON OF TELEPHONE TRANSMISSION SYSTEMS FOR SATELLITE LINKS.
E. K. Sandeman and M. D. Murrell (British Aircraft Corp., Ltd., Stevenage, Herts., England).
IN: INTERNATIONAL ASTRONAUTICAL CONGRESS, 13TH, VARNA, BULGARIA, SEPTEMBER 1962, PROCEEDINGS. VOLUME 2. [A65-19311 09-30]
Edited by Nicolas Boneff and Irwin Hersey.
Vienna, Springer-Verlag, 1964, p. 967-995.

Survey of the comparative merits of single-sideband transmission, frequency modulation, and pulse code modulation incorporated in telecommunications systems. Feasibility, reliability, simplicity, and economy in the satellite and on the ground are considered, along with frequency bandwidth occupancy and required RF power handling capacity in the satellite and on the ground. The key findings are (1) the great economy on bandwidth of the RCA SSB system; (2) the complexity and considerable modifications to existing ground arrangements introduced by any form of PCM; (3) the great simplicity of the on-board PCM equipment, with the RCA system next; and (4) the strong economy of the TWIN 2/6/63 PCM combination with individual coding and constant volume amplifiers (CVA's). It is recommended that the multiple FM system be provisionally adopted as a model on which variations can be made to suit particular satellite systems, that development work be performed to demonstrate the feasibility of SSB from ground to satellite, and that the ground complications introduced by PCM be thoroughly investigated. A reserved opinion is that the RCA system would be preferred if its feasibility can be shown, because of its very small bandwidth occupancy on the up-link. W.M.R.

A65-19337
THE 1970 COMMUNICATION SATELLITE - A HIGH-POWER SATELLITE.
N. I. Korman (Radio Corporation of America, RCA Laboratories, David Sarnoff Research Center, Princeton, N.J.).
IN: INTERNATIONAL ASTRONAUTICAL CONGRESS, 13TH, VARNA, BULGARIA, SEPTEMBER 1962, PROCEEDINGS. VOLUME 2. [A65-19311 09-30]
Edited by Nicolas Boneff and Irwin Hersey.
Vienna, Springer-Verlag, 1964, p. 996-1026. 23 refs.

Description of a high-power communication satellite which utilizes a 60-kw nuclear-reactor power supply. Satellite communications systems now being considered are seriously constrained by satellite power supply problems which limit their transmitters to outputs on the order of 10 w. With the future satellite, spectrum space will be conserved and satellite costs reduced. The cost of ground stations will be lowered, especially for small stations of the sort that would be used in the less affluent countries. In addition, the higher-power satellite will be capable of broadcasting television directly into home and village receivers at lower cost than can be realized by conventional means. It is believed that this will make commercial television more readily available in those areas of the world which cannot afford it or find it impractical for other reasons. (Author) W.M.R

A65-19510 #
A DESCRIPTION OF COMMUNICATION SATELLITES DEVELOPED FOR THE DEPARTMENT OF DEFENSE.
Richard S. Davies (Philco Corp., WDL Div., Palo Alto, Calif.).
IN: AIAA UNMANNED SPACECRAFT MEETING, LOS ANGELES, CALIF., MARCH 1-4, 1965 (AIAA PUBLICATION CP-12). [A65-19498 09-31]
New York, American Institute of Aeronautics and Astronautics, 1965, p. 131-140. 6 refs.

Discussion of the major considerations leading to the design of the DOD communication satellite. Five requirements of a military communications satellite system are considered: (1) early operational date, (2) from one to two duplex voice channels with 20 to 40-foot antenna ground terminals, (3) immunity to countermeasures, (4) high communication reliability, and (5) minimum cost. Discussions of the system design, satellite configuration, orbital altitude, cost factors, accuracy of spin axis orientation, and satellite reliability are presented. Equipment presently under development for flight test is described, and a figure is included showing the breadboard used to perform electrical system interface tests during the summer of 1964. It is emphasized that the development program is well past the breadboard stage and into prototype fabrication. M.L.

A65-19525 #
PRELIMINARY DESIGN OF A LENTICULAR SATELLITE.
Earl Rottmayer (Goodyear Aerospace Corp., Akron, Ohio).
IN: AIAA UNMANNED SPACECRAFT MEETING, LOS ANGELES, CALIF., MARCH 1-4, 1965 (AIAA PUBLICATION CP-12). [A65-19498 09-31]
New York, American Institute of Aeronautics and Astronautics, 1965, p. 285-296.

Presentation of the major structural problems associated with the preliminary design of a gravity-gradient-stabilized lenticular passive communication satellite. The general design features required to implement this concept are described. Factors considered in the selection of the materials are discussed and the material properties are given. Model and component tests performed to substantiate analyses are described and major results given. The critical design conditions are shown for the various structural components, and the resulting stresses or deflections or both are given. (Author) M.L.

A65-19620
CRYOGENICALLY COOLED Y-JUNCTION CIRCULATORS FOR PARAMETRIC AMPLIFIER APPLICATIONS.
R. Damiano and J. Kliphuis (TRG, Inc., Melville, N.Y.).
IEEE, Proceedings, vol. 53, Feb. 1965, p. 198, 199.
Contract No. DA-36-039-AMC-03728(S).

Description of extremely lightweight and small 3-, 4-, 5-, and 7-port circulators developed for use in the military satellite communication band (7.25-7.75 Gc). A figure shows the 7-port circulator, which consists of five Y-junction circulators integrally packaged with two cascaded parametric amplifiers in one single structure. The results obtained with the single 3-port circulator and with multiple-section circulators are shown. It is stated that the proper choice of ferrite material, magnetic field, and construction techniques has kept the variation in circulator parameters with temperature to a minimum over a wide frequency range, thereby eliminating the need for any parameter adjustments with changes in temperature. These properties make these circulators desirable for applications in which the parametric amplifier need only operate at cryogenic temperatures, and it makes them especially desirable in applications requiring operation over the entire temperature range from room temperature down to cryogenic temperatures. M.M.

A65-19651
THE DEVELOPMENT OF COMMUNICATIONS SATELLITES [L'EVOLUTION DES SATELLITES DE TELECOMMUNICATIONS].
J. Chaumeron (Compagnie Française Thomson-Houston, Paris, France).
Revue Française d'Astronautique, Nov.-Dec. 1964, p. 203-215. In French.

Discussion of the various aspects of the development of communications satellites. The subjects considered are: (1) profitable uses of space; (2) active and passive satellites; (3) Score and Courier; (4) passive systems; (5) the first commercial active satellites - Telstar, Relay, and Syncom; (6) stationary satellites of the Syncom type; (7) current state of the art; (8) short-range refinements; and (9) long-range projects. M.M.

A65-19652
ECONOMIC AND POLITICAL ASPECTS OF TELECOMMUNICATIONS BY MEANS OF SATELLITES [ASPECTS ECONOMIQUES ET POLITIQUES DES TELECOMMUNICATIONS PAR SATELLITES].
C. Guépin (Centre National d'Etudes Spatiales, Paris, France).
Revue Francaise d'Astronautique, Nov.-Dec. 1964, p. 216-223. In French.

Brief description of communications satellites and discussion of their principal political aspects. The subjects treated are: (1) communications satellites; (2) communications satellites in the US-creation of the Communication Satellite Corporation; (3) Europe and communications satellites - creation of the European Conference of

Satellites Communications; (4) negotiations and Washington agreements; (5) the US policy after the agreements; (6) Europe after the agreements; (7) communications satellites and the future; and (8) excerpts from the Washington agreements. M. M.

A65-19819

INTERFERENCE BETWEEN AN EARTH STATION OF A COMMUNICATION-SATELLITE SYSTEM AND THE STATIONS OF TERRESTRIAL LINE-OF-SIGHT RADIO-RELAY SYSTEMS.

J. K. Chamberlain (General Electric Co., Ltd., Telecommunications Research Laboratories, Hirst Research Centre, Wembley, Middx., England).

Institution of Electrical Engineers, Proceedings, vol. 112, Feb. 1965, p. 231-241. 18 refs.

Description of a simple method for estimating the mutual interference that may arise between an Earth station of a communication-satellite system and a neighboring line-of-sight radio relay station using the same frequency band. Criteria are suggested for deciding if a proposed mode of Earth-station operation is compatible with recommended maximum permissible values of telephone-channel interference noise. The effect on the interference of the motion of the Earth-station aerial is considered for the principal types of satellite orbit. A number of examples are presented which illustrate the application of the method to an Earth station handling high-capacity fdm/fm transmissions in the 4-Gc and 6-Gc communication bands. P. K.

A65-20598 #

ORDER OF A PERTURBATION METHOD.

Anthony G. Lubowe (Bell Telephone Laboratories, Inc., Analytical and Aerospace Mechanics Dept., Whippany, N.J.).

AIAA Journal, vol. 3, Mar. 1965, p. 568-570. 5 refs.

Demonstration that accuracies usually denoted as second-order (or higher) can be achieved by repeated application of first-order expressions, rather than by derivation of second-order expressions. The difference in approach is analogous to that between existence proofs for solutions of differential equations using Picard iterants instead of dominating series. A numerical example is given. It is postulated that one reason the second-order expressions derived for Telstar orbit prediction are apparently at least ten times more accurate than other second-order methods is this difference in the method of application of the expressions. (Author) M. M.

A65-21304

LAUNCH-PROGRAM SIMULATION FOR VARIOUS COMSAT SYSTEMS.

C. K. Gordon (Douglas Aircraft Co., Inc., Missile and Space Systems Div., Santa Monica, Calif.).

IEEE, Proceedings, vol. 53, Mar. 1965, p. 299, 300.

Brief exposition of a study recently completed along lines similar to those reported in the paper by Sponsler, et al. Three types of Comsat systems (2 planes of 6 satellites each; 18 satellites, random; and 3 planes of 6 satellites each) and four launch programs (all Atlas-Agena; all Tad; all Tat-Agena; all Tasd; and Atlas-Agena for placement and Tad for replacement) were simulated in various combinations. The parameters (inputs) of the simulation model fell under the two headings of Comsat parameters and launch parameters. The results of the simulation runs were in the form of computer outputs which are listed. It is stated that some of the results were, prima facie, rather surprising - i.e., the pronounced effect of satellite cost on expected overall launch-program cost. However, the cumulative costs of a series of failure with a large, expensive booster carrying, in addition, six to eight satellites each costing around half a million dollars, could easily become prohibitive. It was also found that an increase in satellite MTBF from one year to three years plays a significant role in reducing expected overall launch-program costs, as anticipated. However, a further increase in MTBF from three to ten years did not have as pronounced an effect in reducing total expected cost. M. M.

A65-22333

GENERATION OF ORBITAL ELEMENTS FOR THE TELSTAR COMMUNICATIONS SATELLITES.

L. C. Thomas (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).

Bell System Technical Journal, vol. 44, Apr. 1965, p. 603-673. 24 refs.

Description of the technique now regularly in use for the generation of orbital elements for the Telstar communications satellites using angle-only and/or angle-range data vs time as input information. It is found that secular perturbation considerations are sufficient to permit trajectory prediction with pointing errors of about 0.05° over 100 orbits from a single set of elements. Modified orbital elements are chosen as the orbit description, since they explicitly express the secular rates and thereby simplify and reduce the cost of drive tape generations for the Andover ground station. The rates are derived both from perturbation theory and from direct measurement. The size and shape accuracy of the predicted orbit ellipse is improved by statistical means using trajectory data from a number of passes over a particular ground station. This permits better round-the-world predictions. Finally the computer-operator ensemble presently used for generating the orbits of the Telstar satellites is described. (Author) D. P. F.

A65-22383

PROGRESS IN RADIO SCIENCE 1960-1963. VOLUME 8 - SPACE RADIO SCIENCE; UNION RADIO SCIENTIFIQUE INTERNATIONALE (URSI), GENERAL ASSEMBLY, 14TH, TOKYO, JAPAN, SEPTEMBER 15-20, 1963.

Edited by Ken-ichi Maeda (Kyoto University, Dept. of Electronics, Kyoto, Japan) and Samuel Silver (California, University, Space Sciences Laboratory, Berkeley, Calif.).

Amsterdam, Elsevier Publishing Co., 1965. 235 p. $13.50.

CONTENTS:

A65-22386
SPACE COMMUNICATION SYSTEMS - RESULTS AND PROBLEMS.
E. F. O'Neill (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).
IN: PROGRESS IN RADIO SCIENCE 1960-1963. VOLUME 8 - SPACE RADIO SCIENCE; UNION RADIO SCIENTIFIQUE INTERNATIONALE (URSI), GENERAL ASSEMBLY, 14TH, TOKYO, JAPAN, SEPTEMBER 15-20, 1963. [A65-22383 12-07]
Edited by Ken-ichi Maeda and Samuel Silver.
Amsterdam, Elsevier Publishing Co., 1965, p. 129-159. 10 refs.

Brief survey of the background and results of tests with the first experimental active communications satellites. Particular attention is devoted to the results of tests in the Telstar satellite project. Problem areas where progress must be made before a practical operational system can be launched are considered, principally in relation to the realization of a low-altitude random-orbit system. The main problems discussed are methods for obtaining directed radiation from the satellites, reliability and life, delay and echo supression, and simultaneous transmission between several pairs of ground stations through a single satellite.
(Author) D.P.F.

A65-22393
THE OVERALL PLAN OF THE GERMAN WIRELESS STATION AT RAISTING FOR SATELLITE COMMUNICATIONS [DIE DEUTSCHE ERDEFUNKSTELLE IN RAISTING FÜR DIE NACHRICHTEN-ÜBERTRAGUNG ÜBER SATELLITEN - GESAMTPLANUNG].
R. Dingeldey.
(Verband deutscher Elektroingenieure, Hauptversammlung, 53rd, Nuremberg, West Germany, Sept. 28-Oct. 3, 1964.)
Nachrichtentechnische Zeitschrift, vol. 18, Jan. 1965, p. 1-3.
In German.

Description of the installations and data relative to the German wireless communications station at Raisting, specifically designed for tracking the Telstar I satellite. The power output of the satellite's transmitter indicated that an antenna of from 55 to 60 db gain would be necessary, and a parabolic mirror type was selected, with a diameter of 25 meters. Tracking requirements also imposed complete and precise maneuverability, allowing the antenna to be directed at any point in the skies. To allow a clear line-of-sight at low angles with the horizon, the antenna had to be elevated 20 m from ground level. Specific details about the manner in which the transmitter-receiver was coupled to the antenna are given. As a protection against the weather, the whole structure was covered by a transparent plastic film, supported by internal air pressure.
D.P.F.

A65-22394
TECHNICAL DETAILS OF THE GERMAN WIRELESS STATION AT RAISTING FOR SATELLITE COMMUNICATIONS [DIE DEUTSCHE ERDEFUNKSTELLE IN RAISTING FÜR DIE NACHRICHTENÜBERTRAGUNG ÜBER SATELLITEN - TECHNISCHE AUSFÜHRUNG].
R. Herz.
(Verband deutscher Elektroingenieure, Hauptversammlung, 53rd, Nuremberg, West Germany, Sept. 28-Oct. 3, 1964.)
Nachrichtentechnische Zeitschrift, vol. 18, Jan. 1965, p. 3-6.
In German.

Technical performance data relative to the antenna, transmitter, and receiver of the Raisting wireless station. Through a system of reflectors the radio beam is transferred from the focus of the parabolic antenna to the transmitting and receiving equipment, by a waveguide which passes through one of the hollow trunnions serving as the main axles for antenna rotation. This Cassegrainian coupling minimizes losses. Data on the maximum azimuth and elevation figures are given for the antenna, the 2 kw-6390-Mc transmitter, and the 4170-Mc receiver. The receiver uses a liquid-helium-cooled Wanderfeld ruby maser as the RF preamplifier.
D.P.F.

A65-23186
SPIN STABILIZED, SYNCHRONOUS ORBIT SATELLITES.
Harold A. Rosen (Hughes Aircraft Co., El Segundo, Calif.).
IN: ELECTRONICS IN TRANSITION; WINTER CONVENTION ON MILITARY ELECTRONICS, 6TH, LOS ANGELES, CALIF., FEBRUARY 3-5, 1965, PROCEEDINGS. VOLUME 4. [A65-23182 13-09]
Conference sponsored by the Professional Technical Group on Military Electronics of the Institute of Electrical and Electronics Engineers, Los Angeles Section.
Los Angeles, Institute of Electrical and Electronics Engineers, Los Angeles District, 1965, p. IIC-2 to IIC-16.

Review of the Syncom program and predictions of future developments. A brief history is given of the launching and operation of Syncoms 1, 2, and 3. It is suggested that the effective radiated power of these initial systems can be increased by an order of magnitude by using a more directive antenna for the spacecraft-to-ground link. One approach mentioned involves the use of 16 antenna elements, arranged around the spin axis and driven in proper phase to form an Earth-directed pencil beam, which is de-spun electronically as the satellite spins. A new approach to a secure command link for Syncom-type satellites is suggested. It involves using crossed beams for the command-receiver antenna pattern in conjunction with appropriate time gating and logic in the command processor. The use of satellites for television broadcasting is discussed. It is suggested, in this connection, that ground-receiver sensitivity be increased by extending the concept of the uhf signal converter to allow for conversion of microwave frequencies.
A.B.K.

A65-23188
ECONOMIC FACTORS AFFECTING THE INTRODUCTION OF WORLDWIDE COMMUNICATION SATELLITE SERVICE.
Siegfried H. Reiger (Communications Satellite Corp., Washington, D.C.).
IN: ELECTRONICS IN TRANSITION; WINTER CONVENTION ON MILITARY ELECTRONICS, 6TH, LOS ANGELES, CALIF., FEBRUARY 3-5, 1965, PROCEEDINGS. VOLUME 4. [A65-23182 13-09]
Conference sponsored by the Professional Technical Group on Military Electronics of the Institute of Electrical and Electronics Engineers, Los Angeles Section.
Los Angeles, Institute of Electrical and Electronics Engineers, Los Angeles District, 1965, p. IIC-27 to IIC-34.

Consideration of the economic factors affecting the introduction of a global satellite communication system. The traffic needs and requirements which the system will be called upon to fulfill are defined, taking into account the fact that communication requirements have historically been underestimated in most instances rather than overestimated. The technology to build a global commercial satellite system is said to be available, no further basic research and development being required. It is shown that such a system can compete with submarine-cable facilities, if proven and reliable launch vehicles are chosen and satellites with at least 3 to 5 years orbital lifetime are deployed in orbit. Once a system of such satellites has been placed into orbit, significant increases in system capacity can be achieved by improvements in the performance of terminal stations at a relatively small additional cost to the total system.
A.B.K.

A65-23428 #
THE PERTURBATIONS OF SATELLITE ORBITS BY SOLAR RADIATION PRESSURE.
V. V. Radzievskii and Ia. A. Chernikov (Pedagogical Institute, Jaroslavl, USSR).
Astronomical Institutes of Czechoslovakia, Bulletin, vol. 16, no. 1, 1965, p. 1-4; Discussion, L. Sehnal (Czechoslovak Academy of Sciences, Astronomical Institute, Ondřejov, Czechoslovakia), p. 5. 15 refs.

Study of the influence of solar radiation pressure on the motion of the satellite of a planet. The changes are obtained of all the osculating elements during the period of a satellite under the influence of the Sun's direct radiation, taking into account the Poynting-Robertson effect in analytical form. As an example, the numerical values of the variation of the osculating elements of the Echo-1 orbit are calculated. It is shown that the maximum value of the increment of the eccentricity of the Echo orbit is two orders more than was found by Sehnal (1963). The changes of its perigee distance and argument of perigee per single revolution are 6×10^4 cm and 0.4°, respectively.
(Author) D.H.

A65-25142
STATUS OF MILITARY SATELLITE COMMUNICATIONS RESEARCH AND DEVELOPMENT.

J. Wilson Johnston (U.S. Army, Satellite Communications Agency, Fort Monmouth, N.J.).
IEEE Transactions on Military Electronics, vol. MIL-9, Apr. 1965, p. 99-107. 8 refs.

Discussion of the military requirements for satellite communications and the advantages to be accrued through its employment. The current military active satellite communication program is presented, including support of NASA's Syncom program and development of the Defense Communications Satellite System. Areas of research and development for the improvement of initial capability are described, including communication techniques, system approaches, subsystem design, and component development. (Author) V.P.

A65-25421 #
OBSERVATIONS OF WORLDWIDE IONOSPHERIC DISTURBANCES ASSOCIATED WITH SATELLITES.
Martti Tiuri (Institute of Technology, Helsinki, Finland).
COSPAR, International Space Science Symposium, 6th, Buenos Aires, Argentina, May 13-19, 1965, Paper. 7 p. 6 refs.

Review of hf and vhf radar observations of Echo 1(1960 Iota 1) and Echo 2 (1964 4A) which indicate the presence of ionospheric disturbances associated with the satellites. These disturbances can be detected by a north-looking radar, situated close to the northern auroral zone, when a large satellite is passing the magnetic latitude of the radar in either the Northern or Southern Hemisphere. The reflections from the disturbances have no Doppler shift, and their occurrence is dependent on the local time and the heading of the satellite. These phenomena are detected only during magnetic disturbances and are believed to be correlated with magnetic shell enhancements of the upper ionospheric electron density. When a satellite passes such an enhancement, it may trigger a disturbance which can be detected at points close to the corresponding magnetic shell. P.K.

A65-25892
PROBABILITY OF ISOTROPIC LINK CONNECTIVITY USING COMSATS IN ELLIPTIC ORBITS.
Iwao Sugai (System Sciences Corp., Falls Church, Va.).
IEEE, Proceedings, vol. 53, May 1965, p. 541, 542. 6 refs.
Defense Communications Agency Contract No. SD-147.

Proposal of a numerical table of $P_E(P, i, e, \omega)$, the isotropic link connectivity probability using communication satellites in elliptic orbits. Bennett and others have studied connectivity probabilities, but all previous work has been for circular orbits only. B.B.

A65-26987 #
SURVEY OF EXPERIMENTAL SATELLITES AND INTERPLANETARY PROBES, THEIR INSTRUMENTATION, AND THE DATA OBTAINED [PŘEHLED VÝZKUMNÝCH DRUŽIC A MEZIPLANETÁRNÍCH SOND, JEJICH VYBAVENÍ A PROVÁDĚNÝCH MĚŘENÍ].
Petr Lála (Československá Akademie Věd, Astronomický Ústav, Ondřejov, Czechoslovakia) and Jan Vlachý (Československá Akademie Věd, Ústav Fyziky Pevných Látek, Prague, Czechoslovakia).
Československý Časopis pro Fysiku, vol. 15, no. 1, 1965, p. 1-52. In Czech.

Description of the detection methods, instrumentation, type of data obtained, and nation of origin of experimental satellites and interplanetary probes. Such satellites as Telstar and Relay which also have a telecommunications function are also included. The satellites of the Discoverer and Cosmos series are presented in a summary fashion because not much has been published concerning the individual experiments. The overall designs of the satellites and the probes are included in the form of drawings, photographs, and artist's representations. A survey of the satellites according to their experimental functions is also given. M. L.

A65-27466
RELAY SATELLITE COMMUNICATIONS SYSTEM.
J. Kiesling, W. Maco, and S. Goldman (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N.J.).
IN: MICROWAVE SYSTEMS AND DEVICES; FIFTEEN TECHNICAL PAPERS BY RCA SCIENTISTS AND ENGINEERS.
Camden, Radio Corporation of America, Defense Electronic Products, 1964, p. 7-13.

Analysis of the establishment of long-distance high-capacity communication systems using microwave repeaters in Earth-orbiting satellites. The problems involved with the operation of these repeaters in the environment of outer space have been explored using the Relay satellites. The performance objectives and design criteria for the repeaters in the Relay satellite are given, and the ground-station network is described. It is shown that the ground station network, the launch and orbiting constraints, and the outer-space environment impose severe restrictions on the design of this satellite system. B.B.

A65-27852
REDISTRIBUTION OF TRAPPED PROTONS DURING A MAGNETIC STORM.
C. E. McIlwain (California, University, Dept. of Physics, La Jolla, Calif.).
(COSPAR, Meeting, 7th, and International Space Science Symposium, 5th, Florence, Italy, May 8-20, 1964.)
IN: SPACE RESEARCH V; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 5TH, FLORENCE, ITALY, MAY 12-16, 1964, PROCEEDINGS. [A65-27822 17-13]
Organized by the Committee on Space Research (COSPAR) and the Italian Space Research Committee.
Symposium sponsored by COSPAR; International Astronomical Union; International Union of Geodesy and Geophysics; International Union of Pure and Applied Chemistry; International Union of Pure and Applied Physics; and International Scientific Radio Union.
Edited by D. G. King-Hele, P. Muller, and G. Righini.
Amsterdam, North-Holland Publishing Co., 1965, p. 374-391. 9 refs.
Contracts No. NAS 5-1683; No. NASr 116; Grant No. NsG-538.
[For abstract see Accession no. A64-18805 13-28]

A65-27886
PHOTOELECTRIC PHOTOMETRY OF ECLIPSES OF ECHO 2 [PHOTOMETRIE PHOTOELECTRIQUE DES ECLIPSES DE L'ECHO 2].
F. Link, L. Neužil, and I. Zacharov (Académie Tchécoslovaque des Sciences, Institut Astronomique, Ondřejov, Czechoslovakia).
IN: SPACE RESEARCH V; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 5TH, FLORENCE, ITALY, MAY 12-16, 1964, PROCEEDINGS. [A65-27822 17-13]
Organized by the Committee on Space Research (COSPAR) and the Italian Space Research Committee.
Symposium sponsored by COSPAR; International Astronomical Union; International Union of Geodesy and Geophysics; International Union of Pure and Applied Chemistry; International Union of Pure and Applied Physics; and International Scientific Radio Union.
Edited by D. G. King-Hele, P. Muller, and G. Righini.
Amsterdam, North-Holland Publishing Co., 1965, p. 826, 827.
7 refs. In French.

Discussion of the results of photoelectrical measurements conducted during several eclipses of the Echo 2 satellite in 1964. An effect of the absorbing layer of the atmosphere of the earth is indicated at an altitude of 100 to 150 km. V.Z.

A65-27891
PRELIMINARY REDUCTION OF SYNCHRONOUS PHOTOGRAPHIC OBSERVATIONS OF THE SATELLITE ECHO-1.
I. A. Kutuzov (Academy of Sciences, Moscow, USSR).
(COSPAR, Meeting, 7th, and International Space Science Symposium, 5th, Florence, Italy, May 8-20, 1964.)
IN: SPACE RESEARCH V; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 5TH, FLORENCE, ITALY, MAY 12-16, 1964, PROCEEDINGS. [A65-27822 17-13]
Organized by the Committee on Space Research (COSPAR) and the Italian Space Research Committee.
Symposium sponsored by COSPAR; International Astronomical Union; International Union of Geodesy and Geophysics; International Union of Pure and Applied Chemistry; International Union of Pure and Applied Physics; and International Scientific Radio Union.
Edited by D. G. King-Hele, P. Muller, and G. Righini.
Amsterdam, North-Holland Publishing Co., 1965, p. 887-892.
[For abstract see Accession no. A64-18754 13-12]

A65-27892
BALLISTIC CAMERAS - DETERMINATION OF THE POSITION OF BRIGHT MOVABLE OBJECTS AGAINST A FIELD OF STARS [CHAMBRES BALISTIQUES - DETERMINATION DE LA POSITION D'OBJETS LUMINEUX MOBILES SUR FOND D'ETOILES].
J. J. Levallois (Institut Geographique National, Paris, France).
IN: SPACE RESEARCH V; INTERNATIONAL SPACE SCIENCE SYMPOSIUM, 5TH, FLORENCE, ITALY, MAY 12-16, 1964, PROCEEDINGS. [A65-27822 17-13]
Organized by the Committee on Space Research (COSPAR) and the Italian Space Research Committee.
Symposium sponsored by COSPAR; International Astronomical Union; International Union of Geodesy and Geophysics; International Union of Pure and Applied Chemistry; International Union of Pure and Applied Physics; and International Scientific Radio Union.
Edited by D. G. King-Hele, P. Muller, and G. Righini.
Amsterdam, North-Holland Publishing Co., 1965, p. 893-905.
In French.

Discussion of the characteristics of a ballistic camera for photographing bright objects against a background of stars. The 30-cm focal-length camera is provided with a shutter of synchronized to 1 msec and directly controlled by the time signals, for photographing uncontrolled sun-illuminated balloon-type satellites, such as Echo 1 and 2. V.Z.

A65-28568
INTERRUPTIONS OF THE OPERATION OF COMMUNICATIONS SATELLITES AS THEY PASS THROUGH THE EARTH'S SHADOW AND THEIR EFFECT ON COMMUNICATIONS SERVICES [UNTERBRECHUNGEN DES BETRIEBS VON NACHRICHTEN-SATELLITEN BEIM DURCHLAUFEN DES ERDSCHATTENS UND DIE FOLGEN FÜR DEN NACHRICHTENVERKEHR].
H. Weber (Telefunken AG, Backnang, West Germany).
Nachrichtentechnische Zeitschrift, vol. 18, June 1965, p. 308-310.
In German.

Discussion of the effects of the earth's shadow on communications satellites. In order to avoid the interruptions caused by passage through the shadow, communications satellites can be equipped with storage batteries; the latter, however, are heavy and, for low orbits, represent about 10% of the total weight; whereas for high orbits over 10,000 km the figure would be doubled. A better solution is the acceptance of predictable intervals during which communications are interrupted, and provisions for switching from a satellite entering the earth's shadow to another still receiving solar radiation. Various orbits are discussed, including equatorial and polar orbits, in terms of minimizing the interruption caused by satellite eclipse. D. P. F.

A65-28572 #
DETERMINATION OF THE METEOROLOGICALLY LIMITED, LOCAL EXTINCTION VARIATIONS WITH THE AID OF BRIGHTNESS MEASUREMENTS OF THE ARTIFICIAL EARTH SATELLITE ECHO I (1960 IOTA) [BESTIMMUNG METEOROLOGISCH BEDINGTER ÖRTLICHER EXTINKTIONSSCHWANKUNGEN MIT HILFE VON HELLIGKEITSBEOBACHTUNGEN DES KÜNSTLICHEN ERDSATELLITEN ECHO 1 (1960 ι)].
H. Wörner (Meteorologischer Dienst, Meteorologisches Hauptobservatorium, Potsdam, East Germany).
Zeitschrift für Meteorologie, vol. 18, no. 1/2, 1965, p. 13-29.
9 refs. In German.

Determination of the rate of extinction from photographic measurements of brightness of satellite Echo I (1960 Iota), made by Güntzel-Lingner in 1960 in Potsdam, East Germany. An interpretation of the results using selected azimuths and wind directions indicated that there is a maximum toward south-easterly azimuths and easterly wind directions which appears to be due to the influence of the city of Berlin. This is in good qualitative agreement with earlier observations of stars and daylight-hour measurements of solar radiation. A number of requirements for future satellite brightness measurements are established to provide for the determination of the variations of extinction. (Author) D. P. F.

A65-28866 #
COMMUNICATION LINK PERFORMANCE FOR COMMERCIAL AND MILITARY SATELLITES.
Wilbur L. Pritchard and Neil MacGregor (Aerospace Corp., Satellite Systems Div., Los Angeles, Calif.).
(American Institute of Aeronautics and Astronautics, Annual Meeting, 1st, Washington, D.C., June 29-July 2, 1964, Paper 64-416.)
Journal of Spacecraft and Rockets, vol. 2, July-Aug. 1965, p. 614-616. 5 refs.
[For abstract see Accession no. A64-20110 16-32]

A65-29116
TELSTAR TIME SYNCHRONIZATION.
J. M. Steele (National Physical Laboratory, Teddington, Middx., England), W. Markowitz, and C. A. Lidback (U.S. Naval Observatory, Washington, D.C.).
(Institute of Electrical and Electronics Engineers, Conference on Precision Electromagnetic Measurements, National Bureau of Standards Laboratories, Boulder, Colo., June 23-25, 1964, Paper.)
IEEE Transactions on Instrumentation and Measurement, vol. IM-13, Dec. 1964, p. 164-170. 7 refs.

Description of an experiment in time synchronization of clocks in the US and the United Kingdom with the aid of the Telstar I satellite. This experiment was carried out for the purpose of determining the time difference between the master clocks at the U.S. Naval Observatory and the Royal Greenwich Observatory. As an intermediate step, the difference in time between quartz-crystal clocks at the ground stations at Andover, Me., and Goonhilly Downs, Cornwall, was determined, using pulsed signals, 5 μsec long, at the rate of 10 per sec transmitted simultaneously over the satellite circuit from the two stations. The time difference between received and transmitted pulses was measured at each station, and from these results the relative setting of the station clocks was obtained directly. As a result of this intermediate step, the Goonhilly clock was found to be 72.6 ± 0.8 μsec ahead of Andover. The time synchronization between the ground stations was extended to the observatory clocks by low-frequency ground-wave signals propagating with known velocities. The time standard of the Royal Greenwich Observatory was found to be set ahead of the U.S. Naval Observatory by 2234 ± 20 μsec. A.B.K.

A65-29167
PIT SHIELDING FOR COMMUNICATION SATELLITE GROUND-TERMINAL ANTENNAS.
George H. Hagn, Harry A. Turner (Stanford Research Institute, Communication Laboratory, Menlo Park, Calif.), and Michael G. Keenen (Stanford Research Institute, Radio Systems Laboratory, Menlo Park, Calif.).
IEEE Transactions on Electromagnetic Compatibility, vol. EMC-7, June 1965, p. 93-103. 18 refs.
NASA-supported research.

Measurement of the shielding provided for ground-terminal antennas of satellite-to-ground communication links by three one-sided pits of differing geometries. The shielding measurements described were carried out at frequencies of 2.3 Gc (S-band) and 9.0 Gc (X-band), which are in the band now proposed for communication-satellite systems. As a result of these measurements, an isolation of 40 db is thought to be feasible; possibly more could be achieved with specially designed pit walls. A.B.K.

A65-29240 #
THE APPLICATIONS OF RETRODIRECTIVE ANTENNA TO SATELLITE COMMUNICATIONS SYSTEMS AND OTHER SPACE MISSIONS.
Sinclair N. C. Chen and Matthew E. Brady (System Sciences Corp., Space Technology Div., Falls Church, Va.).
IN: NATIONAL AEROSPACE ELECTRONICS CONFERENCE, 17TH, DAYTON, OHIO, MAY 10-12, 1965, PROCEEDINGS. [A65-29228 18-09]
Conference sponsored by the Professional Group on Aerospace and Navigational Electronics, Dayton Section of the Institute of Electrical and Electronics Engineers, and American Institute of Aeronautics and Astronautics.
Dayton, Institute of Electrical and Electronics Engineers, Dayton Section, 1965, p. 95-107. 5 refs.

Demonstration of the advantages and versatility afforded by retroactive antennas, together with an analysis of the results obtained for two specific applications. The two basic types of

retrodirective antennas, namely, the Van Atta array and the so-called phase-conjugation array are described first; similarities and differences in operations of the two types of arrays of various geometrical configurations such as planar, cylindrical, and spherical, are then discussed. Problems common to both types are indicated, and such techniques as array scaling and frequency translation, useful in dealing with some of these problems, are described. Two specific applications of retrodirective antennas are used to demonstrate their attractive features. The first involves the use of retrodirective arrays on a communication satellite launched into a critically inclined elliptic orbit. The second deals with the mutual acquisition problem between two satellites employing retrodirective antennas for space-to-space communication. In the latter application, the finite Markov-chain technique is used to analyze the problem, and the results are compared with those of the corresponding problem where the satellites employ narrow-beam antennas pointing at each other to accomplish acquisition. The acquisition condition which would render a retrodirective system more attractive than a narrow-beam system is indicated.

(Author) A. B. K.

A65-29892 #

INTERNATIONAL EXPERIMENT IN RADIO COMMUNICATION VIA AN ARTIFICIAL EARTH SATELLITE AND THE MOON [MEZHDUNARODNYI EKSPERIMENT PO RADIOSVIAZI CHEREZ ISKUSSTVENNYI SPUTNIK ZEMLI I LUNU].

N. I. Kalashnikov, L. Ia. Kantor, and V. L. Bykov.

Elektrosviaz', vol. 19, July 1965, p. 25-30. In Russian.

Description of the conditions and results of experiments in radio communication between the USSR and Great Britain via the passive earth satellite Echo II and with the aid of signal reflection from the moon. Experiments involving the transmission of unmodulated oscillations, oscillations modulated in amplitude by a tone of 400 cps, and also oscillations modulated by start-stop telegraphic signals, Morse telegraphic signals, facsimile, and speech prolonged in time are evaluated. A. B. K.

A65-31534

ROOM TEMPERATURE IN OUTER SPACE.

J. W. West (Bell Telephone Laboratories, Inc., Mechanical Engineering Dept., Murray Hill, N. J.).

Bell Laboratories Record, vol. 43, July-Aug. 1965, p. 293, 294.

Data on the thermal performance of the Telstar 2 satellite during its two years in orbit. In that time, the electronics package wall temperature stayed within the range of 63 to 83°F. The three main causes of temperature change were (1) seasonal changes in the solar constant, (2) decrease in power dissipated into the package due to degradation of the solar cells in passage through the Van Allen belts, and (3) changes in the optical properties of the satellite skin due to space phenomena. Laboratory tests have singled out plasma-sprayed aluminum as the material most resistant to the high vacuum, UV radiation, and particle bombardment of outer space. The validity of these tests is now supported by the data on the performance of the Telstar satellite. W. M. R.

A65-31591

A NITROGEN-COOLED DEGENERATE PARAMETRIC AMPLIFIER FOR A RADIOMETRIC APPLICATION.

D. Chakraborty and G. F. D. Millward (General Post Office, Research Station, Dollis Hill, England).

Electronic Engineering, vol. 37, Aug. 1965, p. 532-535. 6 refs.

Description of the design of a 6-Gc liquid-nitrogen-cooled degenerate parametric amplifier for use in a radiometer to provide essential knowledge of the gain of the ground-station antenna of a communications satellite system. Antenna gain measurements at both transmitting and receiving frequencies can be made by detecting the noise power from a radio star which has a known power flux density. Two stages, each of 15-db gain and 200-Mc bandwidth to the -3 db-points, are cascaded to provide a minimum gain of 30 db. The inherent bandwidth of the amplifier was adequate for the purpose and special circuits to broaden the bandwidth were not required. The noise temperature of the cooled amplifier is 57°K. The theoretical limit of the sensitivity of a radiometer system using the amplifier is briefly discussed. (Author) M. M.

A65-32299 #

RESULTS OF A RADIO-COMMUNICATIONS EXPERIMENT VIA ECHO 2 AND THE MOON AT A FREQUENCY OF 162.4 MC BETWEEN THE OBSERVATORIES IN JODRELL BANK AND ZIMENKI [REZUL'TATY EKSPERIMENTA PO RADIOSVIAZI CHEREZ "EKHO-2" I LUNU NA CHASTOTE 162.4 MGTS MEZHDU OBSERVATORIIAMI OZHODRELL BENK I ZIMENKI].

G. G. Getmantsev, N. I. Kalashnikov, V. L. Bykov, E. A. Benediktov, L. M. Erukhimov, V. V. Belikovich, V. M. Vakhnin, L. Ia. Kantor, Iu. S. Korobkov, M. V. Kunilov, N. A. Mitiakov, I. M. Puzyrev, V. O. Rapoport, A. G. Sigalov, V. A. Cherepovitskii, and E. A. Akim.

Kosmicheskie Issledovaniia, vol. 3, July-Aug. 1965, p. 618-629. In Russian.

Discussion of the results of 34 events of establishing a communications link at a frequency of 162.4 Mc via the Echo 2 satellite (1964 4A) and the moon between a Soviet and a British observatory. The results obtained with the satellite and the moon are given separately and include signals, such as unmodulated carrier, carrier modulated with a frequency of 400 cps, delayed speech, teletyped signals, and signals in the form of a photoimage. The program and equipment used in the experiment are described.

V. P.

A65-32329

A RUGGED, LOW-POWER, PLANAR CATHODE FOR SATELLITE TRAVELING WAVE TUBES.

Laurence G. Lyon (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).

IEEE Transactions on Electron Devices, vol. ED-12, July 1965, p. 436, 437.

Description of a planar cathode for traveling-wave tubes which are especially well suited for use in spacecraft transmitters because they can be designed to simultaneously provide (1) high gain and power with excellent efficiency, (2) a high degree of reliability, (3) long operational life. The planar cathode in the Telstar TWT uses a unique patented structure which presented design problems ordinarily not encountered in standard communication tubes. Four very stringent requirements were imposed: (1) because of the limited power available, the power drain on the cathode had to be minimized; (2) the cathode would have to withstand successfully a launch environment of high acceleration and severe vibration; (3) a relatively large cathode button had to be rigidly supported to close tolerances of 0.001-in. eccentricity and 0.001-in. tilt. In addition, it would have to endure thermal stresses imposed by brazing, bakeout, cathode activation, and normal operation; (4) finally, its life should be at least 10 yr including thousands of ON-OFF cycles. These objectives have been satisfied with a cathode design which is illustrated. The cathode is described, and ways of realizing low heater power are discussed; strength and vibration capabilities and thermal stresses are also considered. The cathode design as presented here has met the design objectives and has been used successfully in Telstar I and II satellites. M. F.

A65-32351 #

DETERMINATION OF THE COMMUNICATION PERIOD IN SATELLITE COMMUNICATION SYSTEMS.

R. M. Stetsevich.

(Elektrosviaz', vol. 18, Dec. 1964, p. 1-8.)

Telecommunications and Radio Engineering. Telecommunications, vol. 18, Dec. 1964, p. 1-6. 7 refs. Translation.

[For abstract see Accession no. A65-15347 06-07]

A65-32812

MICROWAVE ASPECTS OF FUTURE SATELLITE COMMUNICATIONS SYSTEMS.

Francis D. Boyle (Defense Communications Agency, Communications Satellite Project Office, Washington, D. C.).

(Horizon House, Inc., Annual Microwave Journal Seminar, 4th, New York, N. Y., Mar. 21, 1965, Paper.)

Microwave Journal, vol. 8, July 1965, p. 84-86, 88, 89, 91-93.

Discussion of the Initial Defense Communications Satellite Program (IDCSP) at its present status of development and projected future additions and improvements. The IDCSP system consists of

an X-band frequency translation repeater employing a TWT amplifier which delivers a minimum of 2.5 w to the satellite antenna; the latter is a biconical array that radiates a circularly polarized wave in a toroidal pattern which constantly illuminates the earth as the satellite spins. The ground station complex will consist of two fixed 60-ft terminals and a number of transportable 40-ft terminals now being developed. Power outputs of 35 w for satellite transmitters are projected for the future. At synchronous and near-synchronous altitudes a directive antenna can provide an improvement of 7.5 to 13 db over the present simple toroidal pattern. Future microwave satellite and earth-terminal systems are discussed. D. P. F.

A65-32873
EVOLUTIONARY MEDIUM-ALTITUDE COMMUNICATION-SATELLITE SYSTEMS.
D. I. Dalgleish and A. K. Jefferis (General Post Office, Engineering Dept., London, England).
Electronics Letters, vol. 1, Apr. 1965, p. 37, 38.

Description of a class of medium-altitude communication-satellite systems which may be established by multiple-satellite launch techniques. As the initial satellites fail they are replaced by satellites in slightly different orbits; the system thus evolves into one in which all the satellites follow a common earth track. Multiple-access coverage is in consequence greatly improved. (Author) M. F.

A65-32892
IMPROVED PERFORMANCE OF THE GOONHILLY SATELLITE-COMMUNICATION EARTH-STATION AERIAL SYSTEM.
W. J. Bray (General Post Office, Research Station, London, England).
Electronics Letters, vol. 1, June 1965, p. 108-110.

Description of improvements which were required to enable the Goonhilly satellite-communication earth station to work with the Early Bird satellite. These improvements were achieved by providing a new parabolic reflector surface of greatly increased accuracy, a new design of feed giving greater illumination efficiency, and reduced blocking and scattering from the feed support structure itself. The feeder losses between the feed and the transmitting/receiving equipment have been reduced by using near-square-section overmoded waveguides. The overall improvements are about 4.5 db in the figure of merit (G/T) for reception at 4 Gc and 6.8 db in the transmitting gain at 6 Gc. (Author) M. F.

A65-33560 #
BUNCHING OF SATELLITES IN THEIR ORBITAL PLANE.
Rajendra C. Nigam (System Sciences Corp., Falls Church, Va.).
Journal of Spacecraft and Rockets, vol. 2, Sept.-Oct. 1965, p. 807, 808.

Summary of supplementary equations dealing specifically with spatial and angular bunching of two or more satellites in nearly circular orbits and of the consequences of a particular mode of deployment on the bunching. It is shown that the use of random differential velocities can reduce bunching to the minimum and at the same time ensure a suitable distribution of satellites in orbit to provide the desired coverage for worldwide communications links. M.M.

A65-34001 #
RESULTS OF COMMUNICATION EXPERIMENT CONDUCTED WITH ECHO II SATELLITE.
H. L. Eaker (NASA, Goddard Space Flight Center, Greenbelt, Md.) and J. Ford (Collins Radio Co., Dallas, Tex.).
IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL COMMUNICATIONS CONVENTION, 1ST, BOULDER, COLO., JUNE 7-9, 1965. [A65-33977 22-07]
Convention sponsored by the Communications Technology Group of the Institute of Electrical and Electronics Engineers, National Bureau of Standards, and the University of Colorado.
New York, Institute of Electrical and Electronics Engineers, 1965, p. 271-276. 5 refs.

Observational evidence that there has been no change in the apparent cross section of the Echo 2 satellite from the time it was first observed by the experimenters (during the fifth orbit) until the first phase of the experiments were completed one year after launch. Bistatic experimental data indicate that the satellite is spherical in shape, with no gross surface distortions. Experimental results indicate a satellite bandwidth capability of at least 12 Mc. Amplitude correlation measurements indicate that frequency diversity techniques would become quite effective at a frequency separation of approximately 190 Mc or greater. Excellent results were obtained from facsimile, voice, and music experiments. Except for occasional short bursts of noise during fading, the transmission is clear and virtually noise-free. There is no evidence of any selective fading. Limited tests were performed with Echo 1 during this experimental program. These tests indicate that Echo 2 is superior to Echo 1 as a communication satellite. However, the experimental results from Echo 1 are remarkably good in view of its original configuration and long lifetime in orbit and indicate that the satellite still offers a very useful communication medium. It is concluded that the Echo 2 satellite (in spite of undesirable effects brought about by its rotation) is a very satisfactory reflector for use in passive satellite communication systems. B. B.

A65-34010 #
AN EXTRA WIDE BAND COMMUNICATIONS SATELLITE REPEATER.
D. E. Hershberg and W. L. Glomb (International Telephone and Telegraph Corp., ITT Federal Laboratories Div., Nutley, N. J.).
IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL COMMUNICATIONS CONVENTION, 1ST, BOULDER, COLO., JUNE 7-9, 1965. [A65-33977 22-07]
Convention sponsored by the Communications Technology Group of the Institute of Electrical and Electronics Engineers, National Bureau of Standards, and the University of Colorado.
New York, Institute of Electrical and Electronics Engineers, 1965, p. 323-327.

Description of a wideband communications repeater having broad applicability to both space and terrestrial communications systems. The rf transponder has a bandwidth of 200 Mc, a gain of 100 db, and a power output of 4 watts. An engineering model built to satisfy the requirements of the COMSAT system has been tested. The measured performance has exceeded the requirements for a 1200 channel full duplex CCIR system. (Author) B. B.

A65-34011 #
A VARACTER FREQUENCY MULTIPLIER FOR AN ALL-SOLID-STATE SATELLITE COMMUNICATIONS SYSTEM.
E. E. Bliss and C. D'Elico (Radio Corporation of America, New York, N. Y.).
IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL COMMUNICATIONS CONVENTION, 1ST, BOULDER, COLO., JUNE 7-9, 1965. [A65-33977 22-07]
Convention sponsored by the Communications Technology Group of the Institute of Electrical and Electronics Engineers, National Bureau of Standards, and the University of Colorado.
New York, Institute of Electrical and Electronics Engineers, 1965, p. 329-331.
USAF-supported research.

Description of practical aspects of a frequency multiplier designed for use in the X-band transmitter of a highly reliable, all-solid-state communications system in an experimental satellite. The frequency multiplier is driven by a transistor amplifier at 213.5 Mc to produce outputs at 854 and 6832 Mc. (Author) B. B.

A65-34482
THE EARLY BIRD COMMUNICATIONS SYSTEM.
Albert T. Owens (Hughes Aircraft Co., Culver City, Calif.).
IN: SPACE ELECTRONICS SYMPOSIUM; PROCEEDINGS OF THE

of diffraction of an electromagnetic wave at an inhomogeneous sphere. According to the cross-section method, the field in a waveguide is represented, in the general case, in the form of series of eigenvector functions formed on the basis of membrane functions of the cross section of the corresponding regular waveguide. The problem is then reduced to finding and solving the equations for the coefficients of the expansions of the unknown fields. In the specific case under discussion, the "cross sections" become entire spheres, while the membrane functions become spherical harmonics. The equations for the appropriate field-expansion coefficients and certain general relationships of interest are derived. A. B. K.

A65-34875
COMMUNICATION-SATELLITE RELAYING TESTS BETWEEN USA AND JAPAN.
Ken-Ichi Miya (Kokusai Denshin Denwa Co., Ltd., Tokyo, Japan).
(Japan Electric Machinery Industry Association and Institute of Electric Engineers of Japan, Lecture, Jan. 31, 1964.)
Electronics and Communications in Japan, vol. 47, Apr. 1964, p. 207-215. Translation.

Description of the experimental facilities used, and discussion of the experimental results obtained, in satellite communications between the US and Japan. For the ground station, the Japanese overseas radio and cable system (KDD) in consultation with the Nippon Telegraph and Telephone Public Corp. selected an interference-free site near Takahagi City, Ibaraki Prefecture. The experimental equipment was designed with Telstar in mind. Its general design plans, antenna, transmitter, receiver, tracking and control equipment, power supply equipment, and collimation tower are briefly described. The noise temperature of the receiving system was determined. The experimental plans and the first tracking experiment on Telstar 2 are outlined. Television relay experiments on Relay 1 are described. Results of public television experiments are considered quite good; however, in general, pictures were given a poorer evaluation than were the test patterns. F. R. L.

A65-35055
A SPECTRUM OF SATELLITE ECHO 1.
A. Przybylski (Australian National University, Mt. Stromlo Observatory, Canberra, Australia).
Sky and Telescope, vol. 30, Oct. 1965, p. 217.

Analysis of the spectrum of Echo 1 recorded in Australia. It is noted that, as expected, the satellite spectrum is essentially that of sunlight, although the distribution of energy with wavelength has been modified by the unequal reflectivity of the satellite's surface coating to different spectral regions. The satellite shows fewer features than the stellar spectra, mostly because of its movement at an angle of only 33° to the spectral dispersion instead of at right angles to it. Appearing as one broad band on the objective-prism plate, the H and K lines of calcium are separated on the tracing. The wide band at 3840 Å is mostly due to several strong iron lines, but at its red end cyanogen also produces some absorption. Another strong band in the UV from 3700 to 3760 Å is again mostly due to iron lines. At 4383 and 4405 Å, iron contributes very weak distortions of the curve. M. M.

A65-35179 #
A SATELLITE SYSTEM FOR NAVIGATION AND COMMUNICATION.
E. B. Mullen (General Electric Co., Syracuse, N. Y.) and R. E. Anderson (General Electric Co., Advanced Technology Laboratories, Schenectady, N. Y.).
International Astronautical Federation, International Astronautical Congress, 16th, Athens, Greece, Sept. 13-18, 1965, Paper. 19 p.

Description of a proposed navigation and communication system which utilizes satellites to provide navigation and other information automatically to aircraft and ships. The system is distinguished from a number of other systems also using satellites by the important role played by one or more cooperating ground stations. The ground station initiates a sequence of radio pulses which are relayed to an aircraft or ship via two satellites and are transponded back automatically over the same paths. A computer at the ground station, taking into account the travel times of the ranging pulses and the known satellite positions, calculates a ship's position from the points of intersection of the two circles of position determined by the range distances from the satellites. Aircraft would transmit back, together with the ranging pulses, their altitudes, which are necessary for their accurate position fixing. The position coordinates computed at the ground station are transmitted back via the satellite to the user craft (ship or aircraft) and are automatically displayed there within a second of the first transmission. A. B. K.

A65-35351
ALL-WEATHER EARTH STATION SATELLITE COMMUNICATION ANTENNAS.
J. S. Cook (Bell Telephone Laboratories, Inc., Antenna Research Dept., Murray Hill, N. J.) and A. J. Giger (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).
Bell System Technical Journal, vol. 44, Sept. 1965, p. 1225-1228.

Review of the equipment and techniques that might be incorporated in future commercial and military satellite communication systems. The experiments reemphasized two facts that had been recognized for some time: (1) Worthwhile improvement in the earth station receiver sensitivity could be obtained by elimination of the antenna radome and (2) An important practical improvement would be brought about by the location of the communication and tracking equipment on a platform that does not move with the antenna. Measurements conducted at the Andover Satellite Station during the last 3 years show that in rain or snow the characteristics of the communications system can be seriously degraded in two ways. First, the thermal noise level in the receiving system increases and second, signal loss increases at both the receiving and transmitting frequencies. The susceptibility of an antenna to interfering signals outside the main beam is primarily a function of its side- and back-lobe level. Exposure to the elements brings about a number of antenna problems. Probably the most serious is that of wind loading. M. F.

A65-35708 #
ELECTRIC POTENTIALS, FORCES AND TORQUES ON BODIES MOVING THROUGH RAREFIED PLASMAS.
George P. Wood (NASA, Langley Research Center, Magnetohydrodynamics Section, Hampton, Va.) and Frank Hohl (NASA, Langley Research Center, Hampton, Va.).
American Institute of Aeronautics and Astronautics, and Northwestern University, Biennial Gas Dynamics Symposium, 6th, Evanston, Ill., Aug. 25-27, 1965, Paper 65-628. 66 p. 15 refs.
Members, $0.50; nonmembers, $1.00.

Discussion of the electrodynamic forces and torques on charged bodies moving through the rarefied and partially ionized upper atmosphere and magnetic field of the earth. The charge distribution, the potential distribution, the forces due to increased cross section for ion impacts and to the j x B effect are calculated for Echo 2, which is a sphere 41 m in diameter. The various electrodynamic torques that can affect the spin rate of satellites are examined. These include the surface-charge torque on a rotating satellite, the Coulomb torque due to asymmetric impingement of ions, the eddy-current torque due to rotation in a magnetic field, and the induction torque, both with and without photoemission, due to asymmetry of the j x B force. (The induction torque apparently is treated for the first time.) The results of the calculation of these torques for Echo 2 are applied in an attempt to explain the fact that the spin rate of Echo 2 remained nearly constant for 9 months. It appears that the eddy-current and the induction torques probably were in balance and that the other torques were comparatively small. Another aspect of current interest is the possibility of a transfer of charge between rendezvousing spacecraft, during the docking maneuver, of sufficient intensity to cause damage. There are various phenomena that might conceivably lead to different potentials on two spacecraft and to a current between them on contact. Extreme situations are considered, and it is shown that even for the extreme cases the problem is not severe.
(Author) M. F.

A65-35738
A NONLINEAR PROGRAMMING MODEL IN OPTIMUM COMMUNICATION SATELLITE USE.
T. L. Saaty (United States Arms Control and Disarmament Agency, Washington, D. C.) and G. Suzuki (U. S. Navy, Management Office, Washington, D. C.).
SIAM Review, vol. 7, July 1965, p. 403-408.

Formulation of the problem of allocating communication requirements of different cities via relay-type satellites using a dynamic model over successive time periods, which is in the form of a quadratic nonlinear program requiring integer solutions. The problem is to allocate time to pairs of stations, known as links, for communication purposes. The times in which a satellite, for each of its orbits, is visible are given. The satellites consist of a given number of duplex transmitters where each one has an assigned channel capacity. A diagram illustrating the availability of a satellite transmitter to a given link at time t, where t is divided into discrete units of equal duration, is given. A modified model is described and a method for linearization of the equations is given.
D. P. F.

A65-36200 #
THE EARLY BIRD PROJECT.
Martin J. Votaw (Communications Satellite Corp., Spacecraft Projects Div., Washington, D.C.).
International Astronautical Federation, International Astronautical Congress, 16th, Athens, Greece, Sept. 13-18, 1965, Paper. 13 p.

Description of the following program elements of the Early Bird satellite project: (1) earth station network, (2) European earth stations, (3) future earth stations, and (4) launch and synchronizing operations. The Early Bird system uses modern echo suppressors and has a time delay of 260 msec from earth station to satellite and down to the other earth station. To this must be added an allowance of about 300 msec for the terrestrial networks at both ends. This totals 560 msec for the one way delay and it is appreciably above the CCIR standards. Since little experience is available on commercial satellite circuits, it is important to determine by actual practice whether or not the 560 msec delay is satisfactory. A program of call backs was initiated in the U.S. to call back the users and collect statistical data on the quality of service. After thousands of call backs, it is expected that the statistics will indicate whether or not the satellite circuits provide satisfactory service. Tests of this type are being conducted by the U.S., U.K., France and Germany, and it is expected that the results will be available in Dec. 1965. It may then be possible to determine whether the satellites for the global system will operate at synchronous or medium altitude. M.M.

1966
IAA ENTRIES

A66-11122
PROJECT ECHO OBJECTIVES AND IMPLEMENTATION.
H. L. Eaker (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: WESCON/65; PROCEEDINGS OF THE WESTERN ELECTRONIC SHOW AND CONVENTION, SAN FRANCISCO, CALIF., AUGUST 24-27, 1965, TECHNICAL PAPERS. PART 5 - SPACE ELECTRONICS: SYSTEMS, SPACECRAFT, COMMUNICATIONS. [A66-11109 01-14]
North Hollywood, Calif., Western Periodicals Co., 1965. 10 p. 6 refs.

Discussion of the Echo 2 program to orbit a passive communication satellite which could maintain its spherical shape and smooth surface characteristics in a space environment, even after the loss of its internal inflatant pressure. The design, development, and prelaunch testing of the Echo 2 satellite are reviewed, and its orbital launch on Jan. 25, 1964, is described. Objectives of the Echo 2 program are outlined. P.K.

A66-11123
FULL SCALE GROUND TESTS OF ECHO II PROTOTYPE SPHERES.
James P. Talentino (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: WESCON/65; PROCEEDINGS OF THE WESTERN ELECTRONIC SHOW AND CONVENTION, SAN FRANCISCO, CALIF., AUGUST 24-27, 1965, TECHNICAL PAPERS. PART 5 - SPACE ELECTRONICS: SYSTEMS, SPACECRAFT, COMMUNICATIONS. [A66-11109 01-14]
North Hollywood, Calif., Western Periodicals Co., 1965. 10 p.

Description of full-scale static inflation tests conducted on 135-ft-diam prototypes of the Echo 2 balloon satellite. Four spheres were hung in dirigible hangars and were tested to evaluate their structural and rf backscatter characteristics as functions of their internal pressures. The rf backscatter measurements were conducted at L-band and C-band over a 30-degree section of the spheres. Photogrammetric contour, profile, and skin texture measurements were also made. Despite premature failure in three of the four test spheres, once due to material defects and twice to test appendage stress areas, the ultimate strength was demonstrated to be excellent in the flight quality balloon. P.K.

A66-11124
ECHO II TELEVISION SYSTEM.
J. Yagelowich (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: WESCON/65; PROCEEDINGS OF THE WESTERN ELECTRONIC SHOW AND CONVENTION, SAN FRANCISCO, CALIF., AUGUST 24-27, 1965, TECHNICAL PAPERS. PART 5 - SPACE ELECTRONICS: SYSTEMS, SPACECRAFT, COMMUNICATIONS. [A66-11109 01-14]
North Hollywood, Calif., Western Periodicals Co., 1965. 8 p.

Description of the TV system carried aboard the launch vehicle of the Echo 2 balloon satellite in order to observe the deployment, inflation, and injection into orbit of the satellite. The viewing system provided confirmation, with a high degree of resolution, of canister ejection from the launch vehicle, canister opening and test-sphere deployment, and initial inflation of the test sphere. Design constraints and considerations for the TV system are reviewed, and model studies of proposed TV system designs are discussed. The system design chosen, developed, and flown is described, and its performance during the launch and orbital injection, and the results of the experiment, are discussed. P.K.

A66-11125
THE APPLICATION OF A BEACON TELEMETRY SYSTEM FOR MEASURING ORBITAL PERFORMANCE OF THE ECHO II SATELLITE.
Norman L. Martin and Harold S. Horiuchi (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: WESCON/65; PROCEEDINGS OF THE WESTERN ELECTRONIC SHOW AND CONVENTION, SAN FRANCISCO, CALIF., AUGUST 24-27, 1965, TECHNICAL PAPERS. PART 5 - SPACE ELECTRONICS: SYSTEMS, SPACECRAFT, COMMUNICATIONS. [A66-11109 01-14]
North Hollywood, Calif., Western Periodicals Co., 1965. 9 p.

Description of the radio beacon telemetry system used on the Echo 2 balloon satellite to provide internal pressure, measure skin temperature, and provide optical tracking data. Two telemetry beacons, each consisting of an rf transmitter, two battery packs, and four solar cells, were attached at points 180° apart on the mechanical equator of the satellite. Internal pressure, satellite skin temperature, and beacon temperature (in the orbital environment) were monitored with temperature-sensitive resistance elements. The pressure and temperature histories of the Echo 2 satellite are discussed. The rf beacons also made it possible to evaluate the unexpectedly rapid rotation of the satellite. P.K.

A66-11126
RESULTS OF COMMUNICATION EXPERIMENTS CONDUCTED WITH THE ECHO II SATELLITE.
Wilbur C. Nyberg (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: WESCON/65; PROCEEDINGS OF THE WESTERN ELECTRONIC SHOW AND CONVENTION, SAN FRANCISCO, CALIF., AUGUST 24-27, 1965, TECHNICAL PAPERS. PART 5 - SPACE ELECTRONICS: SYSTEMS, SPACECRAFT, COMMUNICATIONS. [A66-11109 01-14]
North Hollywood, Calif., Western Periodicals Co., 1965. 10 p.

Review of experiments conducted to determine the capability of the Echo 2 balloon satellite as a passive communications device, and to study the shape and surface characteristics of the satellite as a function of time. The tests included facsimile and voice and music transmissions, and measurements of signal level, average scattering cross section, autocorrelation function, and coherent bandwidth. The results indicate that the satellite's shape and surface characteristics did not change appreciably over the year during which the tests were conducted. The tests also show that the satellite provides a very satisfactory reflector for communications purposes, particularly when a special technique, such as frequency diversity, is employed. Tests show an average scattering cross section of 30.2 db, or only 1 db below that for a perfect 135-ft-diam sphere. P.K.

A66-11133
SYNCHRONOUS SATELLITE TECHNOLOGY - ORBIT AND ATTITUDE CONTROL.
Donald D. Williams (Hughes Aircraft Co., Communications Satellite Laboratory, El Segundo, Calif.).

IN: WESCON/65; PROCEEDINGS OF THE WESTERN ELECTRONIC SHOW AND CONVENTION, SAN FRANCISCO, CALIF., AUGUST 24-27, 1965, TECHNICAL PAPERS. PART 5 - SPACE ELECTRONICS: SYSTEMS, SPACECRAFT, COMMUNICATIONS.
[A66-11109 01-14]
North Hollywood, Calif., Western Periodicals Co., 1965. 6 p.

Description of the spin-stabilization system used to control the attitude and orbit of the synchronous Syncom and Early Bird communications satellites. The control system requirements are reviewed, and the procedure for determining the satellite attitude is described. The design and operation of the control and propulsion systems are discussed. The ground control equipment and procedures for control analysis are reviewed, and the results of in-orbit experience with the system are outlined. P.K.

A66-11134
THE EARLY BIRD PROGRAM.
Albert T. Owens (Hughes Aircraft Co., Aerospace Group, Space Systems Div., El Segundo, Calif.).
IN: WESCON/65; PROCEEDINGS OF THE WESTERN ELECTRONIC SHOW AND CONVENTION, SAN FRANCISCO, CALIF., AUGUST 24-27, 1965, TECHNICAL PAPERS. PART 5 - SPACE ELECTRONICS: SYSTEMS, SPACECRAFT, COMMUNICATIONS.
[A66-11109 01-14]
North Hollywood, Calif., Western Periodicals Co., 1965. 4 p.

Description of the commercial Early Bird communications satellite launched Apr. 6, 1965, and placed into a stationary orbit above the Atlantic Ocean. The mechanical and electrical features of the satellite are reviewed. The test program for the project is outlined, and some unexpected problems which arose during its implementation are described. The launch, injection, and in-orbit maneuvers of the Early Bird are reviewed, and some in-orbit tests are described. P.K.

A66-11519
INTERNATIONAL TELEVISION RELAYING BY COMMUNICATION SATELLITES.
Kenichi Miya (Kokusai Denshin Denwa Co., Ltd., Tokyo, Japan).
(Four Electrical Institutes, Joint Meeting, Waseda University, Tokyo, Japan, Apr. 6, 1964, Paper.)
Electronics and Communications in Japan, vol. 47, June 1964, p. 14-23. 10 refs. Translation.

Review of international TV communications using satellite relaying systems. Presatellite TV relaying communication techniques are briefly discussed, including microwave multihop relaying, point-to-point microwave reception, and cable film. Data concerning the Telstar family of satellites are given followed by a description of the Relay group of satellites. The performance and operating characteristics of the Syncom 2 and 3 communications satellites are described. Low-altitude, middle-altitude, and synchronous satellite relaying are discussed as alternatives for proposed commercial communication systems. The effect of frequency sharing, video-bandwidth, and SNR on the quality of reception is considered. D.P.F.

A66-12567
SPURIOUS SIGNALS IN SATELLITE COMMAND SYSTEMS.
James C. Blair (Radio Corporation of America, Princeton, N.J.).
IEEE Transactions on Electromagnetic Compatibility, vol. EMC-7, Sept. 1965, p. 249-262.

The project RELAY command system is described with emphasis given to the spacecraft equipment. Errors in the RELAY command system are discussed, and the probability of error in a single command word and the probability of a spurious command are given as a function of the signal-to-noise ratio (SNR) at the output of the command receiver in the satellite. The performance of the actual RELAY command system is discussed and shown to differ considerably from the performance predicted by theory. The results of an analysis of the orbiting command system are presented. The probable cause for the anomalous performance of the command system is shown to be Radio Frequency Interference from ground based transmitters. The techniques which are available to the system designer to avoid the problems experienced by the RELAY system are discussed in detail. (Author)

A66-12924 #
PHOTOGRAPHIC OBSERVATIONS OF THE PASSAGE OF "ECHO 2" INTO THE EARTH'S SHADOW [FOTOGRAFICHESKIE NABLIUDENIIA VKHOZHDENIIA "EKHO-II" V ZEMNUIU TEN'].
L. M. Genkina, N. N. Denisiuk, and E. S. Eroshevich (Akademiia Nauk Kazakhskoi SSR, Institut Astrofiziki, Alma-Ata, Kazakh SSR).
Astronomicheskii Zhurnal, vol. 42, Sept.-Oct. 1965, p. 1117-1119. 6 refs. In Russian.

Discussion regarding observations of the passage of Echo 2 (1964 4A) into the earth's shadow, made with a meniscus telescope of a focal length of 120 cm, and objective-lens diameter of 50 cm, and a field of view of 5°. The results are applied to the determination of the vertical distribution of aerosoles (of both atmospheric and cosmic origin) and of atmospheric ozone. V.P.

A66-13030 #
PROJECT OF PHOTOELECTRIC OBSERVATIONS OF THE OCCULTATION OF STARS BY ARTIFICIAL SATELLITES OF THE EARTH *FOR GEODETIC PURPOSES* [PROJEKT FOTOELEKTRYCZNYCH OBSERWACJI ZAKRYĆ GWIAZD PRZEZ SZTUCZNE SATELITY ZIEMI DLA CELÓW GEODEZYJNYCH].
B. Kołaczek.
Postępy Astronomii, vol. 13, Jan.-Mar. 1965, p. 17-19. In Polish.

Development of a method for geodetic determinations from photoelectric observations of the occultation of stars by satellites. It is shown that a satellite most suitable for such use should measure several meters in diameter and should possess a brightness of 5 to 6^m. Its orbital altitude should exceed 500 km. The difference in the brightness of such a satellite and that of a star would not impair the observations, as has been the case with Echo 1, while the duration of an occultation would still be on the order of 2 to 3 msec. V.P.

A66-13460
ON THE LOGICAL ESTABLISHMENT OF GLOBAL SURVEILLANCE AND COMMUNICATION NETS.
B. H. Billik and H. L. Roth (Aerospace Corp., Electronics Div., Inglewood, Calif.).
Journal of the Astronautical Sciences, vol. 12, Fall 1965, p. 88-99. Contract No. AF 04(695)-269.

This report establishes criteria for the formation of global surveillance and communication nets and synthesizes some practical examples of these nets. Four properties are postulated which define the necessary conditions for the formation of nets. Certain lower bounds are obtained for the numbers of satellites and/or ground stations in a net in order to establish a worldwide surveillance and communication capability. It is shown that nets can be obtained which are competitive with orbital systems providing only surveillance of the globe. Tradeoffs between the number of ground stations and the number and altitude of satellites in a net are discussed at length. (Author)

A66-13499
SPACE-TECHNOLOGY PROBLEMS OF A COMMUNICATIONS SATELLITE [RAUMFAHRTTECHNISCHE PROBLEMSTELLUNGEN BEIM NACHRICHTENSATELLITEN].
W. von Maydell and H. E. Sass (Bölkow GmbH, Ottobrunn, West Germany).
(Wissenschaftliche Gesellschaft für Luft- und Raumfahrt and Deutsche Gesellschaft für Raketentechnik und Raumfahrtforschung, Jahrestagung, Berlin, West Germany, Sept. 14-18, 1964, Paper.)
IN: SCIENTIFIC ASSOCIATION FOR AIR AND SPACE TRAVEL AND GERMAN ASSOCIATION FOR ROCKET TECHNOLOGY AND SPACE TRAVEL RESEARCH, ANNUAL MEETING, BERLIN, WEST GERMANY, SEPTEMBER 14-18, 1964, JAHRBUCH [WISSENSCHAFTLICHE GESELLSCHAFT FÜR LUFT- UND RAUMFAHRT AND DEUTSCHE GESELLSCHAFT FÜR RAKETENTECHNIK UND RAUMFAHRTFORSCHUNG, JAHRESTAGUNG, BERLIN, WEST GERMANY, SEPTEMBER 14-18, 1964, JAHRBUCH]. [A66-13494 04-31]
Edited by Hermann Blenk.
Braunschweig, West Germany, Friedrich Vieweg und Sohn, 1965, p. 49-53. In German.
[For abstract see issue 23, page 2056, Accession no. A64-26623]

A66-13594
SOME CHARACTERISTICS OF ECHO REFLECTED SIGNALS.
Stephen L. Zolnay and Jon W. Eberle (Ohio State University, Dept. of Electrical Engineering, Antenna Laboratory, Columbus, Ohio).
IN: RECORD OF THE 1965 INTERNATIONAL SYMPOSIUM ON SPACE ELECTRONICS, MIAMI BEACH, FLA., NOVEMBER 2-4, 1965. [A66-13575 04-07]
New York, Institute of Electrical and Electronics Engineers, 1965, p. 5-B1 to 5-B26. 19 refs.
Contracts No. AF 30(602)-2166; No. NAS 5-9507.

This paper presents some of the results of communication experiments that were carried out with Echo 2 during its first year in orbit. The experiments, in turn, serve to evaluate the satellite as part of a communication link. The signals were CW, pulsed CW, and FM at 2.3 kMc/sec, and were reflected by the Echoes in bistatic and almost monostatic configurations. Primary emphasis is on Echo 2 data; numerous results are included from Echo 1 data for comparison. The received signal strength has been observed to fluctuate continuously to the extent of 3 to 5 db. Two to three times as large fluctuations have been noted several times in a 1-min period; the maximum measurable fluctuations were about 20 db and the signals covered this maximum range less often during earlier revolutions, but quite frequently during the latter part of 1964. The Echo area has been observed to be half the calculated one initially; more recently ± 3 db variations about the calculated level have been noted. The autocorrelation function of the signals is presented. From the ACF the specular-to-scattered power ratio of the signal is found and an estimate is made about the periodicity present in the signal and the found value is in good agreement with the rotational period arrived at from other observations. The power spectral density curves were obtained by analog and digital techniques and these are in close agreement. These are apparently composed of two parts. Voice and music experiments are also described. On the basis of data presented it is concluded that the characteristics of both Echo-reflected signals are remarkably similar. (Author)

A66-13595
SYSTEM REQUIREMENTS FOR A DIRECT R.F. TO R.F. REENTRANT TRAVELING WAVE TUBE COMMUNICATIONS SATELLITE TRANSPONDER.
Louis J. Ippolito (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: RECORD OF THE 1965 INTERNATIONAL SYMPOSIUM ON SPACE ELECTRONICS, MIAMI BEACH, FLA., NOVEMBER 2-4, 1965. [A66-13575 04-07]
New York, Institute of Electrical and Electronics Engineers, 1965, p. 5-C1 to 5-C13. 6 refs.

Conventional techniques for obtaining frequency conversion and amplification in an active repeater communications satellite down-convert the received radio frequency signal to an intermediate frequency for amplification and then up-convert to a new radio frequency for further amplification and retransmission. This paper describes the requirements for a reentrant traveling wave tube frequency converter system which accomplishes all amplification and frequency translation at microwave frequencies, eliminating the bandwidth and signal handling limitations of conventional systems employing an intermediate frequency. Transponder requirements for a wideband synchronous orbit communications satellite link are presented and the effects of multiple carriers on the system response are investigated. System and component design criteria are developed for the link and experimental reentrant systems are described. (Author)

A66-13596
MODULATION AND RECEPTION TECHNIQUES FOR SMALL-STATION USERS OF A MULTIPLE-ACCESS COMMUNICATION SATELLITE.
Elie J. Baghdady (ADCOM, Inc., Cambridge, Mass.).
IN: RECORD OF THE 1965 INTERNATIONAL SYMPOSIUM ON SPACE ELECTRONICS, MIAMI BEACH, FLA., NOVEMBER 2-4, 1965. [A66-13575 04-07]
New York, Institute of Electrical and Electronics Engineers, 1965, p. 5-D1 to 5-D8.

Solutions to the "small-station problem" are sought in the design of signals and of ground demodulation techniques. A "small-station" is defined as one whose investment in ground facilities is not adequate for direct demodulation of the entire downlink rf signal from a high-capacity communication satellite. The traffic demands of such a station are normally expected to be considerably less than the full baseband capacity of the downlink signal. The major items in ground station facilities are generally the antennas. The principal disadvantage of a "small-station" relative to a large station lies in its smaller antenna, and perhaps also in its unwillingness or inability to use an ultraquiet rf front end. A downlink signal demodulation technique and associated signal designs are proposed and analyzed to show how significant reductions in ground receiving antenna size can be achieved without sacrificing performance requirements for low-capacity stations utilizing a high-capacity satellite relay. (Author)

A66-13597
CHANNEL CAPACITIES OF MULTIPLE/RANDOM ACCESS COMMUNICATIONS SATELLITE REPEATERS.
D. B. Newman (Institute of Naval Studies, Cambridge, Mass.).
IN: RECORD OF THE 1965 INTERNATIONAL SYMPOSIUM ON SPACE ELECTRONICS, MIAMI BEACH, FLA., NOVEMBER 2-4, 1965. [A66-13575 04-07]
New York, Institute of Electrical and Electronics Engineers, 1965, p. 5-E1 to 5-E11. 5 refs.

Description of a method of estimating the channel capacity of a communications satellite repeater. The link capacities of radio teletype (RATT) and voice channels for hard-limiter and linear repeaters are derived as functions of the various system parameters. The results should be useful in the design of multiple/random access communications satellites. P.K.

A66-13927
BEST SHAPE FOR PASSIVE COMSATS - A DOUBLE LENS.
Earl Rottmayer (Goodyear Aerospace Corp., Akron, Ohio).
Space/Aeronautics, vol. 44, Nov. 1965, p. 106, 108, 110, 112, 114, 116.

Feasibility study showing that cap-type microwave reflectors can be used as communication satellites. The specific requirements of such satellites were worked out for the case of the cap-type equivalent of a 400 ft-diam sphere in a 2000-n mi orbit. This cap has a diameter of 267 ft and a launch weight, including subsystems (for separation, inflation, damping and control), of 1250 lb. A 20-ft model of a lenticular satellite, which is supported by a toroidal structure, is shown. The internal design and the packaging sequence of the torus are illustrated. M. F.

A66-14589
MULTIPLE ACCESS SATELLITE-BORNE REFLEX COMMUNICATION REPEATER APPLIED TO SUPERSONIC AIR TRAFFIC CONTROL.
J. J. Sparagna and D. F. McClinton (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Sunnyvale, Calif.).
IN: NATIONAL ELECTRONICS CONFERENCE, CHICAGO, ILL., OCTOBER 25-27, 1965, PROCEEDINGS. VOLUME 21. [A66-14553 05-09]
Conference sponsored by the Illinois Institute of Technology, the Institute of Electrical and Electronics Engineers, Northwestern University, the University of Illinois, Argonne National Laboratory, Electronic Representatives Association, Scientific Apparatus Makers Association, the Society of Motion Picture and Television Engineers, Iowa State University, Marquette University, Michigan State University, the University of Minnesota, Purdue University, the University of Michigan, the University of Notre Dame, Ohio State University, and the University of Wisconsin.
Chicago, National Electronics Conference, Inc., 1965, p. 313-318. 9 refs.

Study of the application of satellite relay techniques to provide an aircraft-to-ground communications link over the ocean. The feasibility is examined of using a multiple-access satellite-borne reflex repeater to provide continuous line-of-sight digital data links and voice transmission for air traffic control. The basic use of

the relay system, the repeater electronics, and the communication link parameters required to accommodate the satellite-aircraft link geometries are described. Some typical aircraft-ground link calculations are presented, and the basic supersonic aircraft communication requirements and available satellite contact profiles are discussed. P. K.

A66-14604
OPTIMUM RESET OF AN INERTIAL NAVIGATOR FROM SATELLITE OBSERVATIONS 30 JUNE 1965.
B. E. Bona and C. E. Hutchinson (North American Aviation, Inc., Autonetics Div., Research and Engineering Div., Anaheim, Calif.).
IN: NATIONAL ELECTRONICS CONFERENCE, CHICAGO, ILL., OCTOBER 25-27, 1965, PROCEEDINGS. VOLUME 21.
[A66-14553 05-09]
Conference sponsored by the Illinois Institute of Technology, the Institute of Electrical and Electronics Engineers, Northwestern University, the University of Illinois, Argonne National Laboratory, Electronic Representatives Association, Scientific Apparatus Makers Association, the Society of Motion Picture and Television Engineers, Iowa State University, Marquette University, Michigan State University, the University of Minnesota, Purdue University, the University of Michigan, the University of Notre Dame, Ohio State University, and the University of Wisconsin.
Chicago, National Electronics Conference, Inc., 1965, p. 569-574. 8 refs.

Description of a method for recalibrating a shipboard inertial navigation system with periodic position information from a communications satellite. The satellite provides external position information needed to recalibrate or reset the shipboard inertial system. It is shown that optimum control applied at each pass of a satellite with a 90-min period can transform even a relatively inaccurate system (yielding an error in latitude of 8 mi in 24 hr) into a highly accurate one (with an upper bound of 1 mi on the error). P. K.

A66-15170 #
MILITARY COMMUNICATION SATELLITES.
Virgil W. Wall (Aerospace Corp., El Segundo, Calif.).
American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-323. 13 p. Members, $0.50; nonmembers, $1.00.

Review and examination of the decisions made by the USAF as to the type of satellite, dispensing methods, and the system configuration for optimum implementation of a military communications satellite system. The factors that affect and determine the radio frequency to be used are discussed; the frequency chosen lies in the X-band microwave portion of the spectrum. Due to the limitations on the capabilities of solid-state devices at the present time, a TWT amplifier with an output of about 3 watts was chosen; such a device, it is noted, would require a satellite weighing about 100 lb. There is no reason, it is stated, to specify exact altitude for a given satellite, either from the standpoint of booster performance or earth coverage, and the choice would lie between 17,600 and 21,800 miles. The synchronous altitude has many advantages, but requires adequate stabilization; therefore, equatorial orbiting satellites were chosen. D. P. F.

A66-15839
ANTENNAS FOR SPACE COMMUNICATIONS.
Takashi Kitsuregawa (Mitsubishi Electric Corp., Amagasaki, Japan).
Electronics and Communications in Japan, vol. 47, Oct. 1964, p. 54-66. 60 refs.

Review of methods of communicating between ground stations, using space stations as relay agencies, with comparisons of characteristics and economics with ground communication. Passive communication satellites such as Echo 1 and Echo 2 are discussed, and vhf, microwave, and automatic tracking antennas are described. Attention is given to high-gain, low-noise antennas for ground station-to-satellite service. F. R. L.

A66-15907 #
THE USE OF THE 12 HOUR INCLINED ELLIPSE AS A COMSAT ORBIT.
William F. Hilton.
International Astronautical Federation, International Astronautical Congress, 16th, Athens, Greece, Sept. 13-18, 1965, Paper. 11 p.

Analysis of the optimum orbital requirements for Molniia-type communications satellites which are designed to give maximum coverage with low launching costs. Unlike synchronous satellites, which serve some places all of the time, Molniia-type satellites serve many places at specified local times. A 65°/34° orbit for four communications satellites with nodal points 90° apart will result in eight appearances per day, each of which will last more than nine hours. Since the product is 72, this should provide the continuous triple coverage demanded by fail-safe relay stations. The problem of satellite phasing is discussed. The relative advantages and disadvantages of the four satellites proposed vs five or even six stationary satellites are described. D. P. F.

A66-15921 #
EARLY BIRD EXPERIMENTAL RESULTS.
Richard M. Bentley (Hughes Aircraft Co., Aerospace Group, Space Systems Div., El Segundo, Calif.).
International Astronautical Federation, International Astronautical Congress, 16th, Athens, Greece, Sept. 13-18, 1965, Paper. 23 p.

Review of the technical development of Early Bird and discussion of the design objectives and the results of testing. The advantages of a spinning satellite include simplicity and reliability of control, attitude stabilization for antenna beams, and elimination of temperature extremes. To attain the highest quality communications performance every effort was made to improve, where possible, the design parameters of the system. The system is described in all its aspects: structure, power supply, electrical systems, and control system. To achieve the reliability needed for several years of successful operation in space, an intensive program of test and evaluation was undertaken for Early Bird. The results of this test program are tabulated. Based on experience, it is possible to predict an operational life for Early Bird of 18 months. The larger satellites bearing close resemblance to Early Bird, which are in initial development now, will offer much greater radiated power, bandwidth capability, and ten-year stationary control systems. M. F.

A66-16340
COMMUNICATIONS HANDOVER FOR MEDIUM ALTITUDE SATELLITE SYSTEMS.
Andrew Werth (Communications Satellite Corp., Washington, D.C.).
(WESTERN ELECTRONIC SHOW AND CONVENTION, LOS ANGELES, CALIF., AUGUST 25-28, 1964, TECHNICAL PAPERS. VOLUME 8. PART V - COMMUNICATIONS, SPACE ELECTRONICS.)
IEEE Transactions on Communication Technology, vol. COM-13, Sept. 1965, p. 334-340.
Contract No. DA-36-039-SC-90886.
[For abstract see issue 24, page 2188, Accession no. A64-28247]

A66-16399
COMMUNICATION SATELLITE OUTPUT DEVICES. II.
Nathaniel E. Feldman (RAND Corp., Santa Monica, Calif.).
(Rand Corp., Rep. RM-4298-NASA, 1965.)
Microwave Journal, vol. 8, Dec. 1965, p. 87, 89-92, 94, 97. 88 refs.

Review of the current status and performance of such solid state devices as tunnel diodes, transistors and varactor diodes, and of triodes, klystrons, amplitrons and TWT's, within the frequency range of 1 to 10 Gc and for power levels of 0.1 to 100 watts. The current state of technology in TWT heater power, beam efficiency and overall efficiency, including voltage conversion, is presented for TWT's developed for space use. Solid state and TWT transmitters are compared on the basis of efficiency. Loci of equal efficiencies are plotted in the frequency-power domain for operation at a fixed temperature and for operation over a 60°C range. M. F.

A66-16495 #
RECENT DEVELOPMENTS AND PROSPECTS OF COMMUNICATIONS SATELLITES.
V. A. Altovsky (Compagnie Française Thomson-Houston, Groupe Electronique, Bureau des Activités Spatiales, Paris, France).
European Space Flight Symposium, 5th, Munich, West Germany, July 19-22, 1965, Paper. 37 p.

Discussion regarding the traffic needs of communications satellites, and of the possible systems and satellite designs proposed to meet them. Various satellite systems are reviewed and compared, including random-passing, station-keeping (phased-passing), and geostationary satellites. The basic techniques used for launch, in-orbit maneuver, and operation of a phased satellite at medium altitude (such as the Early Bird satellite), as well as of a geostationary satellite are discussed. Some implications of the discussion concerning European research efforts are noted. P.K.

A66-16954
RECENT DEVELOPMENTS AND PROSPECTS OF TELECOMMUNICATIONS SATELLITES [EVOLUTION RECENTE ET PERSPECTIVES DES SATELLITES DE TELECOMMUNICATIONS].
V. A. Altovsky (Compagnie Française Thomson-Houston, Paris, France).
(Symposium Spatial Européen, 5th, Munich, West Germany, July 1965, Paper.)
Revue Française d'Astronautique, Sept.-Oct. 1965, p. 181-194. In French.

Brief review of the status of development and of future possibilities of telecommunications satellites. The most salient characteristics of satellite telecommunications are discussed together with traffic requirements and systems necessary to meet them. A relative comparison is made of the solutions proposed for the implementation of satellites, particularly in the U.S., and their influence on the orientation of European projects of telecommunications satellites is considered. M.M.

A66-17227
RELAY BY COMMUNICATIONS SATELLITES - A SPECIAL SITUATION IN COPYRIGHT INFRINGEMENT LIABILITY.
Omri M. Behr (Merck and Co., Inc., Patent Dept., Rahway, N.J.).
Journal of Air Law and Commerce, vol. 31, Autumn 1965, p. 311-326.

Discussion of some of the legal questions arising from the unlicensed transmission of copyrighted works via communications satellites. The various systems now in operation are considered as well as some which have been broached as being feasible in the foreseeable future. As there are no direct precedents in this area, the analogies of infringement by physical importation and radio transmission are considered. It is seen that the operator of the local receiver/rediffuser is never immune to suit. The original transmitter can most readily immunize himself from being made a party defendant if he utilizes a retransmission satellite to which all release signals originate not from himself, but from the receiver. R.A.F.

A66-17345 #
AN INTERNATIONAL EXPERIMENT ON RADIO COMMUNICATION VIA AN ARTIFICIAL SATELLITE OF THE EARTH AND VIA THE MOON.
N. I. Kalashnikov, L. Ia. Kantor, and V. L. Bykov.
(Elektrosviaz', vol. 19, July 1965, p. 25-30.)
Telecommunications and Radio Engineering. Telecommunications, vol. 19, July 1965, p. 19-24. Translation.
[For abstract see issue 19, page 2759, Accession no. A65-29892]

A66-17440
THE RELAY COMMUNICATIONS SATELLITE - A STUDY IN THE ACHIEVEMENT OF HIGH RELIABILITY.
H. L. Wuerffel and R. P. Dunphy (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N.J.).
Industrial Quality Control, vol. 22, Jan. 1966, p. 355-363. 5 refs.

Outline of the stages of development of the Relay communications satellite with special emphasis on the achievement of system reliability. After describing the mission requirements, a basic system which will meet the functional requirements is formulated. This system is then modified and expanded to meet the reliability requirements. Problems of fabrication and assembly are considered. The testing program to ensure flightworthiness is discussed, and actual performance in orbit is compared with predicted performance. A.B.K.

A66-18084
STUDIES OF TRAPPED RADIATION BY THE TELSTAR I AND EXPLORER XV SATELLITES.
W. L. Brown (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).
IN: PLASMA SPACE SCIENCE SYMPOSIUM, CATHOLIC UNIVERSITY OF AMERICA, WASHINGTON, D.C., JUNE 11-14, 1963, PROCEEDINGS. [A66-18072 07-30]
Edited by C. C. Chang and S. S. Huang.
Dordrecht, Netherlands, D. Reidel Publishing Co., 1965, p. 189-209; Discussion, p. 209-211; 254-260. 21 refs.

Discussion of specific cases of important connections between the natural plasmas in space and the particles trapped within the magnetosphere. It is noted that, in the cases treated, present understanding is extremely primitive if it exists at all. Consequences of the special plasmas created by nuclear explosions in space are considered. Data obtained with Telstar I and Explorer 15 - well within the magnetosphere at maximum radial distances of about 4 earth radii and at latitudes of less than 50° - are analyzed, and particle trapping mechanisms are considered. M.M.

A66-18563
THE EXPERIENCE WITH TELSTAR.
Eugene F. O'Neill (Bell Telephone Laboratories, Inc., Murray Hill, N.J.).
(Conference on Civilian and Military Uses of Aerospace, New York, N.Y., Jan. 11-14, 1965, Paper.)
New York Academy of Sciences, Annals, vol. 134, Nov. 22, 1965, p. 167-178. 7 refs.

Review of operational experience gained with the Telstar communications satellite, with emphasis on those factors of significance for the design of long-life satellites. The transmission characteristics of the communication system using Telstar are described. The thermal design of Telstar is reviewed, and the temperature histories of the satellite and its solar cell array are discussed. The behavior of the satellite spin rate and spin-axis orientation is examined. Radiation exposure and damage to the satellite are discussed. P.K.

A66-18568
WORLD-WIDE CIVILIAN COMMUNICATIONS SATELLITE SYSTEM CONCEPT.
Edwin J. Istvan (Communications Satellite Corp., Washington, D.C.).
(Conference on Civilian and Military Uses of Aerospace, New York, N.Y., Jan. 11-14, 1965, Paper.)
New York Academy of Sciences, Annals, vol. 134, Nov. 22, 1965, p. 234-244.

Discussion of some implications of the worldwide communications capability available through the use of satellites. The establishment of the Communications Satellite (Comsat) Corporation is reviewed, and agreements between the U.S. and foreign governments on a global communications satellite system are discussed. The program and timetable for the establishment of this system are described, and different system concepts are discussed. P.K.

A66-18569
WORLD-WIDE MILITARY COMMUNICATIONS SATELLITE SYSTEM CONCEPTS.
Jay J. Cohen (U.S. Defense Communications Agency, Communications Satellite Project Office, Washington, D.C.).
(Conference on Civilian and Military Uses of Aerospace, New York, N.Y., Jan. 11-14, 1965, Paper.)
New York Academy of Sciences, Annals, vol. 134, Nov. 22, 1965, p. 245-249.

Discussion of the use of a communications satellite system to help meet the need for reliable, long-distance military communications. The Defense Communication Satellite Program is reviewed. This program will provide a satellite system of high survivability, reliability, security, and flexibility with global coverage and potential for growth. The background and objectives of the program are reviewed, and the characteristics of the proposed system are outlined. P.K.

A66-18681
DESIGN AND ELECTRICAL PROPERTIES OF THE 25-M GROUND-STATION ANTENNA AT RAISTING FOR RADIO COMMUNICATIONS VIA SATELLITES [DIMENSIONIERUNG UND ELEKTRISCHE EIGENSCHAFTEN DER 25-M-ANTENNE DER ERDEFUNKSTELLE RAISTING FÜR NACHRICHTENVERBINDUNGEN ÜBER SATELLITEN].
G. v. Trentini, K.-P. Romeiser, and W. Jatsch (Siemens und Halske AG, Zentrallaboratorium für Nachrichtentechnik, Munich, West Germany).
Frequenz, vol. 19, Dec. 1965, p. 402-421. 18 refs. In German.

Discussion of the design and performance of the Cassegrainian antenna installed at the Raisting ground station for radio communications via satellites. The antenna has a 25-m parabolic reflector with a focal length of 6.5 m, is housed in an air-inflated dacron radome, and can be oriented in both azimuth and elevation. Its broadband feed system is composed of a horn reflector positioned at the vertex of the main reflector and of an auxiliary reflector installed in the nearfield of the horn reflector to correct the phase front of the primary wave. The noise contribution from the sidelobes and the radome is 9 to 13°K, and the tracking accuracy is given as higher than 1/100°. The aperture-blocking and feedhorn spillover effects in low-noise antennas with paraboidal and rotationally symmetrical reflectors are investigated. V.Z.

A66-18713
TIME DIVISION ACCESS FOR MILITARY COMMUNICATIONS SATELLITES.
R. M. Hultberg, F. H. Jean, and M. E. Jones (System Sciences Corp., Falls Church, Va.).
IEEE Transactions on Aerospace and Electronic Systems, vol. AES-1, Dec. 1965, p. 272-282.

Simultaneous use of a single satellite repeater by several surface terminals is of considerable interest to the military user. A method of achieving multiple access by means of time division is described. Bursts of digital data from different surface terminals are interleaved in a manner that allows them to be identified and demodulated. A comparison is made between the access efficiency of time division and that of other methods of multiple access. It is shown that, for a range of conditions, time division compares favorably with the others. In addition, it has the major advantage of flexibility. The primary considerations in the design of a system are given and the pertinent relationships derived. These relationships are used to obtain the values of the system parameters for an illustrative system model. The system described allows six different accesses at any one of three data rates, depending on the carrier-to-noise ratio. Finally, a system block diagram is given with a description of its operation. (Author)

A66-18947
DESIGNING A SATELLITE GROUND STATION RECEIVING SYSTEM.
R. G. Slaughter, J. A. Cone, and R. A. Miller, Jr. (Thompson Ramo Wooldridge, Inc., TRW Systems Group, Redondo Beach, Calif.).
Microwave Journal, vol. 9, Jan. 1966, p. 83-86, 88, 90-94. 26 refs.

Discussion of the system design considerations involved in selecting a receiving system for a medium-capacity satellite ground station. The postulated satellite system is assumed to transmit telephony by FM over a 6 Gc carrier with a multiplex signal. System design criteria, system noise temperature, and antenna efficiency are discussed. The relative advantages of different types of parametric and maser amplifiers are evaluated. Six possible combinations of antenna, feed, and preamplifier systems which satisfy or almost satisfy the system sensitivity requirement of about 35 db are presented in a table. Careful consideration of relative costs, sensitivity, reliability, and optimum feeds indicates that the optimum choice would be a 60-ft antenna with a closed-cycle Gifford-McMahon parametric amplifier with Cassegrain feed. D. P. F.

A66-19396 #
TRAPPED PROTONS OF THE INNER RADIATION BELT.
R. Walker Fillius (Iowa, State University, Iowa City, Iowa).
Journal of Geophysical Research, vol. 71, Jan. 1, 1966, p. 97-123. 47 refs.
Contracts No. NAS 5-1683; No. NASr-116; Grant No. NsG-538.

Satellite Relay 1 has performed a thorough mapping of the energy spectrum and spatial distribution of protons in the inner zone. New intensity maps are presented in this paper for six energy ranges between 1.1 and 63 Mev as of Jan. 1, 1963. With these six distributions and previously published intensities in two more ranges, accurate energy spectra can be constructed at arbitrarily selected locations throughout most of the inner zone. The Relay 1 data compare favorably with those of other experiments and unify our knowledge of the proton distributions. In any energy range the maximum intensity is found at the equator, and varies along a line of force near the equator as the third or fourth power of 1/B. There are fewer high-energy than low-energy protons, and they are found closer to the earth. Sample intensities are $j = 3.7 \times 10^6$ cm^{-2} sec^{-1} ster^{-1} from 1.1 to 14 Mev at $L = 2.2$ on the equator and $j = 1.6 \times 10^4$ cm^{-2} sec^{-1} ster^{-1} from 18.2 to 25 Mev at $L = 1.6$ on the equator. Neutron albedo sources, both cosmic ray and solar proton sources, are weaker than required by as much as four orders of magnitude at 1 Mev. Adiabatic breakdown theories are in disagreement with the spatial dependence of the energy spectrum and cannot be controlling factors. Injection and diffusion of solar wind particles is a possible source, but more theoretical work is needed to clarify the expected results. (Author)

A66-19508
OMEGA LOCATION AND SATELLITE REPORTING FOR WORLD-WIDE OBSERVATION SYSTEMS.
C. R. Laughlin and G. E. Hilton (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL EAST COAST CONFERENCE ON AEROSPACE AND NAVIGATIONAL ELECTRONICS, 12TH, BALTIMORE, MD., OCTOBER 27-29, 1965. TECHNICAL PAPERS. [A66-19487 08-21]
Conference sponsored by the Baltimore Section of the Institute of Electrical and Electronics Engineers, and the Aerospace and Navigational Electronics Group.
New York, Institute of Electrical and Electronics Engineers, 1965, p. 2.1.2-1 to 2.1.2-7.

Discussion of considerations for a combined satellite/ground station system for global data collection. The Omega system, a vlf navigation network, is reviewed. System concepts and design parameters for both low-orbiting and synchronous satellite systems are discussed. The manner in which these satellite systems could be used together with the Omega network to provide an operational global data-reporting system is described. P.K.

A66-19514
SIMULATION OF A SATELLITE MAGNETIC STABILIZATION SYSTEM IN AN AIR BEARING FACILITY.
David N. Dittmar (Westinghouse Electric Corp., Atomic, Defense and Space Group, Aerospace Div., Baltimore, Md.).
IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL EAST COAST CONFERENCE ON AEROSPACE AND NAVIGATIONAL ELECTRONICS, 12TH, BALTIMORE, MD., OCTOBER 27-29, 1965. TECHNICAL PAPERS. [A66-19487 08-21]
Conference sponsored by the Baltimore Section of the Institute of Electrical and Electronics Engineers, and the Aerospace and Navigational Electronics Group.
New York, Institute of Electrical and Electronics Engineers, 1965, p. 2.2.4-1 to 2.2.4-11.

Discussion of the use of a three-axis airbearing facility to test a coils-only magnetic torquing attitude control system. The control system was developed for a large spherical balloon satellite of the Echo type. The control system is described, and the procedures used to simulate satellite motion and the orbital magnetic environment are reviewed. The results of these tests are discussed. P. K.

A66-19537

MEASUREMENTS OF THE STRENGTH AND POLARIZATION OF VHF SIGNALS FROM A SYNCHRONOUS ALTITUDE SATELLITE.

Thomas H. Barton (Federal Aviation Agency, Systems Research and Development Service, Research Div., Atlantic City, N. J.).

IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, ANNUAL EAST COAST CONFERENCE ON AEROSPACE AND NAVIGATIONAL ELECTRONICS, 12TH, BALTIMORE, MD., OCTOBER 27-29, 1965. TECHNICAL PAPERS. [A66-19487 08-21]
Conference sponsored by the Baltimore Section of the Institute of Electrical and Electronics Engineers, and the Aerospace and Navigational Electronics Group.
New York, Institute of Electrical and Electronics Engineers, 1965, p. 3.3.4-1 to 3.3.4-7.

Discussion of the diurnal variations observed in the strength and polarization rotation of 136-Mc signals transmitted from the synchronous Early Bird satellite. The techniques and equipment used to make these measurements are described. The results are discussed in terms of their implications for a vhf communications link with aircraft via synchronous altitude satellites. P. K.

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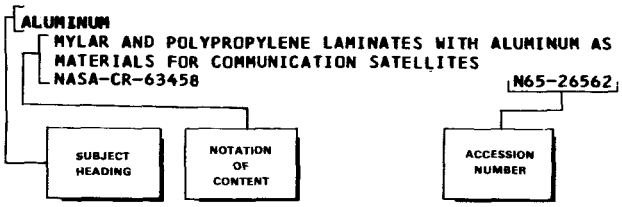

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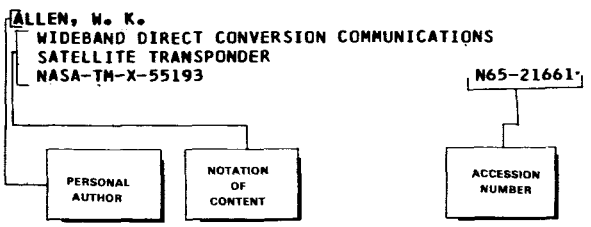

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